CHANGES IN SMUTGRASS (*Sporobolus poiretii* [Roem. and Schult.] Hitchc.) GROUND COVER INDUCED BY SPRAYING WITH MOLASSES AND GRAZING MANAGEMENT

By

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CHANGES IN SMUTGRASS (Sporobolus poiretii [Roem. and Schult.] Hitchc.) GROUND COVER INDUCED BY SPRAYING WITH MOLASSES AND GRAZING MANAGEMENT

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A grazing experiment was conducted at the Beef Research Unit, Gainesville, Florida, from April to November 1976. The experimental area was a pasture of 'Pensacola' bahiagrass (Paspalum notatum Flugge), smutgrass (Sporobolus poiretii [Roem. and Schult.] Hitchc.). White clover (Trifolium repens L.) was present in the spring. The initial ground cover of smutgrass was estimated to be between 40 and 50% and bahiagrass was the dominant desirable specie.

The purpose of this research was to determine the effects of different combinations of lengths of rotation grazing cycles and levels of grazing pressures on the control of smutgrass and to evaluate the effect of spraying molasses upon the palatability of smutgrass, compared to the unsprayed treatment.

Molasses was diluted in equal parts of water and sprayed at the rate of 320 liters/ha of molasses prior to introducing the animals. Grazing pressures measured in terms of residual dry matter left after grazing were 0.5, 1.3, 2.1, 2.9, and 3.7 metric tons/ha, and lengths of rotation cycles were 0, 14, 28, 42, and 56 days.

Thirteen different combinations of the 2 factors were arranged in a response surface design and superimposed upon the control and molasses sprayed treatments. The axial, center, and corner points were replicated twice, making a total of 22 pastures per main treatment. Smutgrass ground cover was estimated in early April before applying the treatments and again late in October, 1976.

Spraying molasses to the pasture resulted in little increase of palatability of smutgrass when compared with the control treatment. The attractiveness of sprayed smutgrass was lost a few hours after spraying.

In both treatments, smutgrass ground cover decreased with increasing grazing pressure. Smutgrass ground cover was influenced very little by length of rotation cycle.

Stocking rate, when considered as a response variable, expressed either as animals/ha/day or liveweight/ha/day, increased with increasing grazing pressure. Length of rotation cycle had little effect.

INTRODUCTION

Weeds, whether herbaceous or woody, are undesirable in pastures because they compete with forage plant species for moisture, nutrients, and light. The extent of this competition depends as much on the growth habit and nature of the weed species as on their density and distribution. Also, many weeds harbor some of the worst crop insect pests and are alternate hosts to organisms causing crop diseases. Other weeds may be poisonous, causing reduced weight gains, lowered animal production or even death.

Weed control is a major need in any program of management. The primary objective of weed control in pastures is to selectively manipulate the canopy to eliminate undesirable plant species while maximizing the production of desirable species. The complexity of weed control requires inputs from a wide variety of specialties spanning plant ecology and physiology, management, and economics. Recommended weed control measures must be implemented as long-term programs without damaging desirable plants. This concern is an integral part of the research effort and a vital consideration.

Most weed problems on grazing lands result from man's activities with the introduction of exotic plants being a prime cause. For example, smutgrass (Sporobolus poiretii [Roem. and Schult.] Hitchc.) was introduced into the United States from tropical Asia. It is now a serious problem in many pastures of the southeast, particularly on the sandy soils of Florida.

Smutgrass, in pasture, spreads through enlargement of original plants and dissemination of seeds. However, density serious enough to threaten forage production may not be recognized until 5 to 10 years after being introduced into new areas.

Control of smutgrass on heavily infested areas has long been recognized as an effective pasture improvement practice. During the past 15 years several methods have been developed to control this weed. Generally, these methods can be divided into three main categories: mechanical, chemical, and combinations of the two. Mechanical methods, such as mowing and cultivation are not effective in controlling smutgrass and previous chemical control methods have failed to give acceptable selective smutgrass control in established pastures.

In the selection of the control method, not only should degree of smutgrass kill and cost be considered, but also the effect of the treatment upon the associated forage species.

No information is available on the effect of grazing management systems alone or combined with other weed control practices upon smutgrass. Since many pastures in Florida are infested with smutgrass, it is important to find out how much control of this weed can be reached when grazing management is used with other practices.

The objectives of this study were to determine a) the effects of different combinations of lengths of rotation cycles and levels of grazing pressure on the control of smutgrass, and b) the applicability of spraying molasses on the pasture in an attempt to enhance the palatability of smutgrass and thereby increase smutgrass acceptability.

REVIEW OF LITERATURE

Smutgrass

Sporobolus poiretii [Roem. and Schult.] Hitchc. is named smutgrass because of a hyphomicete, Bipolaris (Helminthosporium) ravenelii (Curt.) Schoemaker, (Luttrell, 1976), which often infects the panicles and at times is found in patches on the leaves (Currey and Mislevy, 1974). It was observed that seeds produced during the spring were not heavily infested with B. ravenelii while the seeds produced in the fall were (Currey et al., 1973).

Smutgrass has been described on numerous occasions (Hitchcock, 1936, 1950; Swallen, 1955). It is a deep rooted, caespitose perennial of the family Graminea. The grass is glabrous, summer growing, with culms erect, solitary or in small tufts, 30 to 100 cm high. The leaf blade is flat to subinvolute, rather firm, 2 to 5 mm wide at the base, elongated, and tapering to a firm point toward the end. The panicles are 15 to 30 cm long, usually spike-like, plumbeous, dense, the branches appressed floriferous to the base or nearly so. The spikelets are each 1.7 to 2 mm long; glumes are obtuse, the first 0.5 and the second from 0.5 to 0.7 mm long. The seeds are reddish when mature and may remain for some time, sticking to the panicle by the mucilaginous pericarp.

Seeds are spread by water, and wind and by sticking to livestock. Smutfree seeds may remain on the panicle for some time or shatter quickly depending on the weather (Mislevy and Currey, 1975). Seed production is continuous from May to December, with flowering, immature seed,

mature seed, and seed shattering occurring simultaneously on a single inflorescence on the same plant (Currey et al., 1973). A mature plant produces in excess of 45,000 seeds with over 1,400 seeds per panicle. Germination averaged less than 9% while mechanical scarification of the hard seed coat improved germination up to 94%. Currey et al. (1973) concluded that smutgrass exhibits characteristics associated with a very successful weed due to 1) production of large numbers of seed per season, 2) production of seed continually over the entire growing season, 3) variable seed dormancy with germination over an extended period of time, and 4) continual maturation of seed on each inflorescence of the same plant.

On a global scale, smutgrass is found in Asia, Central, South and North America, and West Indies (Hitchcock, 1906, 1936, 1950; Roseveare, 1948; Molinari, 1949; Swallen, 1955; Sacco, 1964) from sea level to approximately 2,700 m. It is adapted to most soil types and especially where rainfall exceeds 40 inches annually (Riewe et al., 1975b). It apparently was introduced into the United States from tropical Asia (Hitchcock, 1950) and occurs along roadsides, lawns, pastures, and wasteland from Virginia to Tennessee and Oklahoma, south to Florida and Texas. It has been reported in New Jersey and also along the Oregon Coast. Smutgrass has become adapted to subtropical and temperate climates. Top growth is killed by frost but regrowth occurs the following spring.

Smutgrass is an undesirable, weedy grass on considerable hectarage of pasture and rangeland across the southeastern United States (Riewe et al., 1975b; Smith et al., 1974; McCaleb et al., 1963). In Florida, McCaleb et al. (1963) first reported smutgrass as a potential threat to forage quality in permanent pastures and a recent survey (Currey and

Mislevy, 1974) of some central and south Florida counties indicated that 75% of the improved pasture was infested with smutgrass. The average level of infestation was 38%. It is slow to establish and usually requires several years before a heavy infestation occurs (McCaleb et al., 1963) but if the first few plants in the pasture are not brought under control, they will become the dominant specie in the field. The infestation increases from year to year through extension of the original plants and also from the growth of seedlings. According to Carter (1961), a heavily infested pasture may have as many as 24 plants per square yard and they may vary in size from one to six inches or more in diameter.

The acceptability of smutgrass by livestock as a forage is considered low. McCaleb et al. (1963) stated that lack of palatability of smutgrass is particularly evident on the mineral soils of Florida and Georgia and Currey et al. (1973) added that this characteristic helped to account for the high level of infestation presently observed in Florida pastures. In Texas, Riewe (1974) reported that smutgrass produces a low quality forage, palatable to livestock only in the spring, but that after May, cattle will graze it only when forced to. According to Carter (1961), this weed is not palatable to cattle and the carrying capacity of the pasture tends to decrease with increasing smutgrass infestation. In another study (Smith et al., 1974) it was reported that production of high quality forage is greatly reduced as smutgras increases in the pasture.

What causes unpalatability of smutgrass is not known. In this respect (Mislevy and Currey, 1975) suggested that palatability may be limited by the high fiber content (82%) found in the mature plant.

Persad (1976) studied the nutritive value of smutgrass and 'Pensacola' bahiagrass. In vitro organic matter digestion and neutral detergent fiber of smutgrass were higher than of bahiagrass after 6 weeks growth. He suggested that after 6 weeks of growth, it is possible that low digestibility associated with high neutral detergent fiber could be the primary factor limiting the acceptability of smutgrass.

Smutgrass Control

A review of the available literature has failed to reveal any information on the control of smutgrass specifically in relation to grazing management. Control methods that have been used include mechanical, cultural, chemical, and combinations of mechanical and chemical (McCaleb et al., 1963; Smith et al., 1975; Currey and Mislevy, 1974).

In 1955, McCaleb et al. (1963) attempted to control smutgrass with mechanical methods. They studied the effect of rotary mowing at a 3-inch height at intervals of 1, 2, 3, and 4 weeks. They reported that control of smutgrass by mowing at weekly intervals resulted in some reduction of plant size but that all plants recovered to former density after stopping the treatment. Cultivation and complete renovation gave variable and unsatisfactory results, since new plants grew from seeds already in the soil. In Louisiana, the use of a modified rotary tillage machine resulted in 90 to 95% reduction of smutgrass (Carter, 1961).

Many chemicals have been evaluated to determine their effect on smutgrass. McCaleb et al. (1963) screened 6 different chemicals for their herbicidal efficiency on control of smutgrass. In this preliminary trial several herbicides showed promise, including dalapon (2,2-dichloropropionic acid), monuron TCA (3-[p-chlorophenyl]-1,1-dimethylurea

mono [trichloro acetate]) and monuron (3-[p-chlorophenyl]-1, 1-dimethylurea). They reported that with dalapon at the rate of 5 lb/acre of active ingredients, the control averaged 85%. Despite the results, they pointed out that additional treatments were necessary to kill surviving plants and new bunches starting from seed. When using a single fall application of either bromacil (5-bromo-3-sec-butyl-6-methyluracil) at 2.24 kg/ha or atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine] at 4.48 kg/ha, Smith et al. (1974) reported 83 to 95% control of smutgrass within 36 weeks. In Texas, Riewe et al. (1975a) stated that almost complete smutgrass control prevailed 18 months after spraying with dalapon at a rate of 5.6 kg/ha. However, they added that reinfestation of the treated pasture should be expected in time. In Mississippi (Smith, 1975), spring application of dalapon and diuron controlled 90% of the smutgrass in bermudagrass (Cynodon dactylon [L.] Pers.).

Herbicides may injure desirable species in the pasture, although grass species vary in their reaction to herbicides. Severe leaf damage and root kill of bahiagrass with very slow recovery of surviving plants was observed with a rate of 5 lb/acre of dalapon (McCaleb et al., 1963; McCaleb and Hodges, 1971). On the other hand, Riewe (1974) found that all top growth of common bahiagrass was desiccated at the time of dalapon application, but recovery began 4 to 6 weeks after application. He concluded that bahiagrass seems to be quite tolerant to dalapon at the rate of 4.75 lb/acre of active material. Houston et al. (1975) studied the effect of atrazine and dalapon upon smutgrass control in a dallisgrass (Paspalum dilatatum Poir)-bermudagrass pasture. They

found that atrazine was the least damaging to desirable species, while dalapon was the least selective. Dalapon delayed recovery of the two species for approximately 3 weeks. Minimum damage to a dallisgrass and bermudagrass has been achieved with a late October application, after most of the desirable forage had been grazed off by cattle (Riewe, 1975b).

The time of herbicide application seems to be very important to the control of smutgrass. In Florida, Currey and Mislevy (1974) reported that the best time of the year to apply dalapon is late May, when the plant is most actively growing. Houston et al. (1975) suggested that pastures can be sprayed any time between May and October if conditions are favorable and smutgrass is growing. They also pointed out that if early herbicidal application causes shortage of forage due to damage of the desirable species, dalapon could be applied between late September and early October. When applied in the spring or early summer, dalapon increases the loss of grazing time and other weeds generally become a more serious problem (Riewe et al., 1975b; Schlundt, 1977). In a study to determine the effects of applications of dalapon in March, May, June, August, September, and October, Riewe (1974) concluded that applications in late summer and fall are the most successful. He concluded that application at this time resulted in a) less loss of grazing, b) fewer weeds, and c) fits well into a program of seeding ryegrass into a warm season perennial grass pasture for winter pasture.

Combinations of spraying with mowing have not been explored sufficiently in smutgrass control. In Florida, Currey and Mislevy (1974) studied different cultural treatments before and after application of

dalapon at rates of 4 and 5 lb/acre. They reported that smutgrass can be controlled by mowing to a 2-inch stubble 4 to 5 weeks following the application of dalapon. It was observed that 2.5 years after such a treatment combination, little smutgrass encroachment in 'Pangola' digitgrass (Digitaria decumbens Stent.) and bahiagrass occurred, provided the treated pasture was fertilized and rotationally grazed (Mislevy and Currey, 1975).

Weed Control by Grazing Management

Effective control of weeds may often be obtained by mechanical means such as mowing or cultivation or by treatment with herbicides, but costs will always need to be considered (Leach et al., 1976). Chemical control may be essential where toxic weeds have become established and hazardous to livestock. Michael (1970) pointed out that grazing management studies designed specifically for weed control have as yet barely begun in Australia. He added that this kind of study is much needed, especially in relation to weedy grass and annual grass control. Smith (1968) stated that control of barley grass (Hordeum leporinum Link) by grazing management presents advantages over chemical methods because a) it is cheap, b) the weed is a useful source of forage in its early stage, and c) clover production rather than being lost, may even be increased.

Michalk et al. (1976), in Australia, studied the effect of different stocking rates under 6 grazing management systems on the control of barley grass. Heavy grazing in late winter increased the proportion of barley grass in the pasture and the number of seedheads per unit area.

However heavy grazing early in the fall resulted in decrease of the weed and increase in crow-foot (Erodium spp). They concluded that dry matter production for the different treatments was relatively unaffected. However, there was a marked effect on botanical composition and on the development and flowering of the different species particularly in the case of barley grass.

The effect of grazing management on slender thistle (Cardus pycnocephalus L.) population in an improved pasture was studied in southern Tasmania (Bendall, 1973). Deferring grazing until winter or spring was very effective in reducing slender thistle. Spring grazing favorably altered pasture botanical composition by increasing the frequency of perennial ryegrass (Lolium perenne L.) and subterranean clover (Trifolium subterraneum L.) and reducing the frequency of the weed. He concluded that, of the other successful treatments, deferred fall grazing is the most practical system for incorporation into the farm management system as an alternative to herbicide for the control of slender thistle. He also indicated that such a program has the advantage of being less expensive than chemical treatment and favors general pasture improvement.

Myers and Squires (1970) observed for 3 successive fall seasons the effect of grazing on the control of barley grass in an irrigated pasture sown with subterranean clover. He compared grazing starting 10, 20, and 40 days after the opening of irrigation. Barley grass yield was less on the 20-day treatment than on the 10 and 40 days. Deferment of grazing for 10 days was less successful, because of the tendency of the animals at this early stage to select dead material and warm-season

weeds in preference to barley grass. They concluded that substantial reduction in barley grass population in an irrigated pasture can be achieved within 1 year, and that almost complete elimination will occur in two years by deferment of grazing for 20 days followed by continuous grazing management.

In Australia from 1962 to 1966, the influence of pasture topdressing with superphosphate and stocking rate on skeleton weed (Chondrilla juncea L.) in a white clover-ryegrass mixture was measured in a grazing experiment (Kohn and Cuthbertson, 1975). The increase in stocking rate from 5 to 15 sheep per hectare had no effect on final skeleton weed number. Density of skeleton weed increased in rotational grazing (1 week grazing and 2 weeks rest) when compared to continuous grazing. The increase of the weed under rotational grazing was due to the development of satellite plants in the pasture.

Laycock (1970) compared the effect of spring-fall grazing and fall grazing only on a sagebrush-grass range. Heavy spring grazing caused a reduction of grasses and forbs by more than 50% from 1950 to 1964 and increased sagebrush production by 78%. Fall grazing enhanced production of palatable perennial grasses by 36% and reduced production of sagebrush by 22%. He suggested that fall grazing as a method for range improvement is less expensive than mechanical or chemical means of sagebrush control.

For 4 years, Pearce (1972) studied the consequence of different stocking rates on the control of Patersons's curse (Echium plantagineum). He found that population of Paterson's curse declined by up to 72% with a stocking rate of 3 sheep per acre and up to 80% when the stocking rate was increased to 8 sheep per acre. Pasture sprayed with

2,4-D and grazed at a stocking rate of 8 sheep per acre had considerably lower weed population than pasture which was not sprayed.

Southwood (1971) reported control of broomrape (Orobanche minor) in a Trifolium subterraneum-Hordeum leporinum pasture mixture. Heavy, continuous grazing before the broomrape flowered combined with superphosphate application in autumn, significantly reduced the weed population. The author stated that when continued for a number of years, broomrape could be eradicated by such a treatment combination.

Pasture Loss Due to Weeds

Weeds contribute to decrease pasture productivity in several ways: 1) they decrease forage yield due to weed competition, 2) they cause animal discomfort, 3) they result in undesirable flavors in animal products, and 4) they may cause poisoning of the grazing animals (Smith, 1974). The average annual losses due to weeds in pastures and rangelands in the United States from 1951 to 1960 may be estimated at more than $632 millions (Hamill, 1975). In 1973 in Florida, it was estimated that weed damage in pasture and hay crops totaled 28.8 million dollars. This cost resulted from expense of weed control with herbicides and mechanical methods, yield and forage quality loss, lowered land value, and the expense of additional harvesting (Smith 1974). This figure does not include animal losses in decreased weight gains, less milk production, and animal deaths by poisoning.

Weeds interfere with the growth and development of desirable forage species in many ways. They compete for light, water, nutrients, space, and carbon dioxide (Smith, 1974; Hamill, 1975). Crombie (1947) defined

competition as the requirement at the same time by more than one living organism for the same resources of the environment in excess of the immediate supply. Daubenmire (cited by Risser, 1969) suggested the following parameters of adaptation which may under specific circumstances, be significant in competiton: 1) time of root penetration. 2) ability to obtain nutrients in short supply, 3) endurance in drought soils, 4) longevity, 5) abundance of seed production, 6) food reserves available to young plants, 7) time of initial growth, 8) nutrient uptake ability, 9) vigor and size of plant, and 10) reproductive potential.

In a comprehensive study in Australia to examine the outcome of competition for light between capeweed (Arctotheca calendula) and subterranean clover, McIvor and Smith (1973) reported that capeweed does not suppress clover growing in association if the two species commence growth together. However, when the capeweed was established 4 weeks before clover, the legume yield was always lower than from pure stand sown on the same day.

Rummell (1946) investigated the competition of Bromus tectorum L. with Agropyron desertorum (Fisch. ex Link) Shult. and A. smithii Rydb. In this study the number of A. desertorum plants was reduced to 50% and A. smithii to about 10%. He concluded that A. desertorum which germinates earlier in the season and makes rapid growth following emergence, competes more successfully with B. tectorum than the slower developing A. smithii.

Wakefield and Skaland (1965) conducted an experiment with alfalfa (Medicago sativa L.) to evaluate effects of intra-species and weed competition on seedling establishment. Seeding rates of alfalfa were approximately 25, 50, and 100 seeds per square foot. Three intensities

of weed competition were developed with the aid of chemical treatments. They found that weed control resulted in an increased yield of alfalfa in the seeding year compared to untreated plots. Seeding rates had a marked effect on the average root-crown weights of alfalfa. Smallest weights occurred at the high seeding rate and significantly larger root-crown weights were observed from the lowest seeding rate.

Grimmett and Weiss (1967) investigated the competition of weeds in sown pasture of 'manawa' ryegrass (Lolium perenne L. x L. multiflorum Lam.) and subterranean clover. They reported that rapid weed growth restricted seedling development of the desirable species resulting in slow and unsatisfactory pasture establishment.

Bryan and McMurphy (1968) reported in their study that crabgrass (Digitaria sanguinalis [L.] Scop.) which emerged with the seeded weeping lovegrass (Eragrostis curvula [Schrad.] Nees.) reduced forage yield by more than one-half in the first clipping. The plants which suffered from weed competition were visibly reduced in height and did not produce seedheads the first year.

Scholl and Staniforth (1957) studied the establishment of birdsfoot trefoil (Lotus corniculatus L.) as influenced by competition from weeds. They found that pre-emergence application of monuron TCA or post-emergence application of dalapon controlled grassy weeds and enhanced survival and vigor of trefoil seedlings.

Benefits from Weed Control

Beneficial effects of weed control on pastures depend on the efficiency of the weed control method. Klingman (1970) stated that what was most needed to produce good quality pasture was a method to prevent

and eliminate weeds. He also suggested that in pasture-forage production, the integration of all beneficial practices into the management system is required to achieve highest efficiency.

Peters and Stritzke (1971) studied the effects of 2,4-D and mowing on the botanical composition and production of a Kentucky bluegrass (Poa pratensis L.). They reported that the average production of broadleaf weeds were 88, 329, and 950 lb/acre for 2,4-D, mowed and untreated plots, respectively. Yields of Kentucky bluegrass were 900 and 1,150 lbs/acre for the control and 2,4-D treatments, respectively. They concluded that the forage yield increase was primarily the result of a decrease in competition from broadleaf weeds.

Alley and Bohmont (1958) studied the control of big sagebrush (Artemisia tridentata Nutt.) in a native pasture. They indicated that a four-fold increase in yield of native forages was obtained by controlling big sagebrush.

In a four-year study, Morrow and McCarty (1976) observed the influence of green sagewort (Artemisia campestris L.) and other broadleaf weeds on forage production in Nebraska. Chemical treatment increased forage production by 42% and controlled 97% of the weeds in plots receiving two consecutive annual applications. Forage production was increased up to 330 for herbicide alone and 660 lb/acre of dry matter for herbicide followed by nitrogen fertilization. They pointed out that herbicide and fertilizer can be effectively used to increase forage production, but they will not correct the effect of mismanagement which results in weedy pastures.

In Nebraska, Klingman and McCarty (1958) reported that use of 2,4-D was more efficient than mowing for the control of broadleaf weeds.

Using three annual applications of 2,4-D reduced the weeds by 70% and mowing alone resulted in a reduction of 30%. Combining annual spraying with plowing and seeding reduced broadleaf weeds more than 90%.

Scholl and Brunk (1962) investigated the competition of weeds with birdsfoot trefoil. They compared no weed control and all weeds removed in the early stage of growth. Where no weeds were controlled, yield on the trefoil on the first year was 389 lb/acre of dry matter and where complete control was practices, 2,342 lb/acre of dry matter was obtained also in the first year. In the second year the yields were 3,480 and 6,533 lb/acre of dry matter for the control and weed-free treatments, respectively. Birdsfoot trefoil plants were shorter on the control treatment than on weed-free treatment. However there was no difference between the two treatments as far as birdsfoot trefoil population was concerned.

Gesink et al. (1972) investigated the control of broom snakeweed (Gutirrezia sarothrae [Pursh] Britt and Rusky) on the short-grass plains in southeastern Wyoming during 5 years. Control of broom snakeweed increased the desirable species, chiefly blue grama (Bouteloua gracilis (H.B.H.) Lag.). Herbage production was 225 lb/acre of dry matter for untreated areas and 1,200 lb/acre of dry matter when treated with a herbicide.

Forage quality and intake may be increased by controlling weeds in pastures. Barrett et al. (1973) studied the effect of spraying paraquat in a pasture containing subterranean clover and either silver grass (Vulpia spp.) or ripgut brome (Bromus rigidus Roth). Spraying controlled the grasses and produced pastures containing up to 95% clover.

The concentration of N, P, Ca, and Mg were higher in mature herbage on treated plots than on the control treatment.

Monson (1977) studied the effect of paraquat on yield and quality in a pasture of Coastal bermudagrass (Cynodon dactylon L.). He found that the in vitro dry matter digestibility of a sprayed pasture was higher than on the control at 6 weeks after treatment application.

Smith et al. (1974) determined the quality of forage produced after controlling smutgrass in a Paspalum dilatatum Poir.-Cynodon dactylon L. pasture. It was observed that soluble cell contents were significantly higher in the treated plots. The acid detergent fiber and neutral detergent fiber fractions were decreased by application of herbicide. He pointed out that the figures for nutritive value index suggest that intake of digestible dry matter should be higher in pasture where smutgrass was controlled when compared to the control.

In most experiments the forage intake has been increased by controlling weeds. After four years of weed control and fertility treatments in a Kentucky bluegrass pasture, Peters and Stritzke (1971) found significant improvement in the intake of forage. Low fertility treatment with 2,4-D increased consumption of edible forage (Kentucky bluegrass, legumes, and weed grasses) about 200 lb/acre, but the medium and high levels of fertilization in combination with herbicide increased intake about 600 and 1,000 lb/acre, respectively.

Klingman and McCarty (1958) compared spraying and mowing for weed control and measured the effect of the treatments on forage intake. They reported that dry matter intake was 1,650 pounds on the sprayed pasture and 1,340 pounds on the mowed as compared to 1,124 pounds on the untreated plots. That represented an increase in forage consumption of 47% for spraying and 19% for the mowing.

Measuring Botanical Composition

The determination of the species in a pasture is important for studying the changes in botanical composition due to treatment effects. Botanical composition is also essential because individual species may differ in theri reaction to environmental and management factors. (t' Mannetje et al., 1976).

Measurement of botanical composition may be made in terms of the yield of the species components, the frequency of occurrence of different species and the number of plants on the area covered by different species (t' Mannetje et al., 1976).

The area ground covered by the aerial parts of the plants has proven to be a valuable measure of botanical composition and its change. Brown (1954) defined cover as the vertical projection of the above-ground parts of the plants on the ground, and it is expressed as a percentage of the total area (Winkworth et al., 1962). Terms used to express the area covered are 1) density, 2) basal area, 3) herbage area, 4) foliage density, 5) cover, and 6) leaf area index.

Pasture research had led to the development of a large variety of methods for estimating percent cover (Brown, 1954). The methods fall into four basic categories, depending on the type of observation made and the dimensions of the sampling unit. These are charting, ocular estimates, line intercepts, and point methods.

The chart quadrat method is one of the earliest techniques used to determine changes in botanical composition (Hill, 1920). Basically, the ground position of each plant is drawn in its relative position on a recorded sheet (Weaver and Clements, 1938), usually at yearly intervals (Wright, 1972). However, Brown (1954) stated that the interval between

charting depends on the purpose of the study. He emphasized that in areas where weather varies considerably from year to year an annual charting is important to determine the changes in the vegetation.

Hutchings and Pase (1962) stated that chart quadrat method is particularly well suitable to grass and other types of low vegetation. However, he added that this technique presents better results when the plants are clearly defined in bunches or tufts. It becomes more difficult as the growth becomes closer and is quite impossible in dense pastures (Brown, 1954).

Heady et al. (1959) compared the accuracy and practicability of charting, line intercept, and line point in the sampling of two shrub communities. They reported that means and confidence intervals obtained by the three methods gave reliable estimates of the population mean. Line intercept and line point yielded less variable data and were sampled adequately with fewer plots and less time than the charting methods. However, Ellison (1942) found that accuracy in charting method depends on the ability and care of the operators and to some extent on the charting device used.

Although the chart quadrat method can provide a reasonably accurate record of the vegetation (Holscher, 1959), it is always time consuming. The individual culms as well as the area occupied by clumps must be carefully drawn into a small scale quadrat map with the aid of a pantograph or directly by means of numerous wires crossing the frame (Anderson, 1942).

Estimating Forage Yield

Sampling to estimate yield is one of the most difficult procedure involved in pasture research. The methods generally used for

measuring the production of a pasture involve the cutting of areas or spot samples of the pastures. As stated by Campbell et al. (1962), the use of grazing animals in pasture management studies increases the difficulty of estimating yield from sample-cutting techniques due to a) the need to cut sufficient samples to give an accurate estimate of the yield, because of the very variable nature of grazed pasture, b) the requirement of cutting as few samples as possible, which arises from the physical limitations on cutting large number of samples, and c) the need to ensure that the area cut is not so large that it acts as a treatment in itself.

Many efforts have been devoted to the search of a quantitative method for determining the yield of pasture in situ. Bransby et al. (1977) emphasized that a rapid, indirect, in situ, nondestructive technique for making accurate estimates of pasture dry matter yield would benefit grazing experiments. The literature describing the methods that have been developed which do not require the harvesting of herbage usually refer to the term "density." The use in each instance is in accordance with the use of the term for the specific method and is based on the relationship as stated by Mott (1962).

Yield/Unit Area = f (density, height)

One of the more promising methods of estimating pasture dry matter yield in situ is the use of electronic capacitance meter (Alcock and Lovett, 1967). Fletcher and Robinson (1956) proposed the use of a capacitance meter. It is based upon the fact that herbage has a high dielectric constant and air has a low dielectric constant. Readings were taken from plants under conditions ranging from dry grasses to soggy, wet sedges in swamp land. They demonstrated that the

capacitance meter showed promise of being faster than clipping and more accurate than other estimation methods. They reported that the slight decrease in precision per determination is more than offset by reduction in sampling error. Campbell et al. (1962) with a modified capacitance meter stated that if the errors of prediction were solely random error, the greater efficiency of sampling by the instrument would compensate for any moderate increase in error per estimate compared with a cutting technique. Johns and Watkin (1965) reported that the great advantage of using a capacitance meter is that once the apparatus has been calibrated for a particular pasture, a very large number of readings can be taken in a short time with no detrimental effect on the pasture.

In New Zealand, Campbell et al. (1962) found that within pastures the capacitance meter allows an estimate of sample yield to be made with considerable accuracy. The instrument predicted about 90% of the variation in forage weight either as wet, dry or organic matter. For different pastures significant differences existed between prediction equations, although certain pastures can be combined. They concluded that for different pastures, individual prediction equations would be required. Johns and Watkin (1965) studied the relationship between capacitance readings and yield of pastures. They found that in all pastures except for native pasture, the regression of dry matter yield, fresh material and total water on the meter reading were highly significant. However, the dry matter regressions were generally slightly inferior to both the fresh material and total water regressions. They suggested that dry matter is still considered adequate for use in individual experiments where the particular regression could be reliably

established, even though regression based on yield of fresh material would be more accurate. In Colorado, Carpenter et al. (1973), studied the influence of woody stems on the relationship of the capacitance meter to herbage weight. A single meter reading of the plot estimated weight of total herbaceous material is more accurate than total herbaceous material plus woody stems. They reported that excluding wood would probably improves the regression because woody material has little capacitance relative to herbaceous material and the amount of wood on the plots varied greatly relative to the amount of herbaceous material.

It is apparent that the height of the forage and the above stubble height affect capacitance meter readings. Hydy and Lawrence (cited by Alcock and Lovett, 1967) found that a change in capacitance of the probe is caused by the dielectric properties of the herbage and plant acting as a circuit when leaves come into contact or near contact with the electrodes. Lovett and Bofinger (1970) used a capacitance meter to measure growth of 30 cultivars of rape (Bassica spp.). The height of some cultivars exceeded the height of the probe, resulting in plant material touching the top plate of the instrument. Under such conditions probe readings were affected by changes both in capacitance and a tactile factor, the latter occurring when material was crushed down in down in obtaining readings.

When measuring a short stubble the main factor influencing change in capacitance is the dielectric properties of the herbage (Hydy and Lawrence; cited by Alcock and Lovett, 1967). Back et al. (1969) sampled plots sown with Lolium multiflorum Lam. and a grass-white clover (Trifolium repens L.) mixture. On each plot, 5 samples were cut to ground level and a further five to approximately 2 cm above

ground. They reported higher relative efficiency of the samples cut to 2 cm in comparison with those taken to ground level.

A critical factor in obtaining a close relation between capacitance meter readings and dry matter yield of cut forage is the water content. Johns and Watkin (1965) studied the effect of dew on capacitance meter readings. They pointed out that the presence of heavy dew on the pasture enhanced the dial reading by approximately 1.2 units. This increase would represent an apparent increase of approximately 125 lb/acre of dry matter in the estimate of pasture yield. They concluded that this over-estimation of dry matter yield varies with the amount of dew, the moisture collecting and retaining ability of the species present in the pasture and the amount of surface moisture when the readings are taken. In further investigations, Alcock and Lovett (1967) determined the influence of surface-water upon capacitance meter readings. Plots of Italian ryegrass were sprayed at the rates of 0, 2,750, 5,500, and 11,000 gallons of water per acre. Readings of the meter increased with the level of water added to the pasture. However, they reported that estimated dry matter yield varied very little. In a similar study, Jones and Haydock (1970) reported that application of water resulted in increased readings followed by a decline as the water dripped off the plants. They concluded that unlike the marked effect of water applied to the plants, there was little effect from adding water to the soil beneath the probes. Flooding the area and allowing the water to soak-in had very little effect provided the soil surface was level.

Neal and Neal (1973) reviewed the use of electronic capacitance meters to estimate weight of standing vegetation. They concluded that variation in site and phenology generally have more influence on meter performance than does meter design. In their explanation, the meter reading is the sum of numerous external influences and internal characteristics of the instrument. They emphasized that the technique is accurate, rapid and nondestructive when used properly. However, Nichols (1973) stated that any apparatus for outdoor use must be designed so that adverse conditions do not contribute to further inaccuracy. Shaw et al. (1976) pointed out that the capacitance meters have not lived up to their early promise due to limitations such as a) it measures water yield in the plant tissues and not dry matter yield, b) it is influenced by plant species, and c) it is relatively insensitive where the herbage consists mainly of dead material. He concluded, however, that the above limitations apply much more often in the case of tropical pasture than temperate pastures.

Spraying Pasture with Molasses

It has long been known that consumption of unpalatable forage is influenced by adding molasses. The direct application of molasses on standing pasture, seems to have first been developed in South Africa (Loosli and McDonald, 1968). Plice (1952) advised farmers to take advantage of this technique and get rid of weeds, unpalatable and poor-quality forage by spraying them with molasses or other similar product, and turning grazing animals on them.

Change in intake from preferred to initially non-preferred components of the pasture is enhanced by inducing the animals to graze heavily on the sprayed area in preference to grazing lightly over the whole pasture (Willoughby and Axelsen, 1960). In this respect, Coombe and Tribe (1962) also stated that only small areas of the pasture should be sprayed with molasses at a time. Native pastures with considerable amount of unpalatable annual grasses were sprayed with urea-molasses mixture during the summer (Pope et al., 1955). They reported that spraying a small area led to very intensive grazing and removal of all top growth, while spraying a large area resulted in an incomplete consumption of the sprayed forage.

According to Coombe and Tribe (1962) spraying molasses on standing herbage presents several disadvantages. They emphasized that the most serious is the high proportion of spray which falls on the soil and is washed off by rain. In addition, they added that the technical difficulties of spraying forage may be considerable where a) pasture areas are large, b) stocking rates are low, and c) the ground surface is rough. Mostert (1959) emphasized the importance of spraying only thick grass stands or patches, otherwise much of the sprayed mixture will be wasted. In detailed tests on one cattle pasture, it was found that only 16.5% of the spray could be recovered from the herbage immediately after spraying (Loosli and McDonald, 1968).

In Oklahoma, Plice (1952) compared table sugar, black-strap molasses, sorghum molasses, and corn syrup when sprayed on weeds and grasses which are seldom, or never, touched by grazing animals. The order of preference for the different materials was as follows: black-strap molasses,

sorghum molasses, table sugar, and corn syrup. He observed that the animals did not take very long to discover the sprayed plants and then consume them completely.

In Australia, Willoughby and Axelsen (1960) tested four spray treatments, containing urea, molasses, and urea plus molasses on a grass-legume mixture which had been ungrazed in the spring and had matured and dried in early summer. The pastures sprayed with molasses were consumed most rapidly by the animals. The application of sprays, mainly molasses, resulted in increased removal of the most abundant component, Phalaris, an initially non-preferred component of the pasture. He concluded that spraying affected intake in three ways: a) it provided a supplement, b) it altered the amount of forage consumed, and c) it increased or decreased the quality of the material consumed, depending on whether the non-preferred components are higher or lower than the preferred in nutritive value.

O'Bryan (1960) examined the utilization by cattle of carpet grass (Axonopus affinis Chase) following foliar application of urea, molasses, and monosodium phosphate in southeastern Queensland. The pastures provided a complete ground cover and were sprayed in strips at weekly intervals. He reported that the animals showed preference for the treated strips immediately after spraying. The treatment failed to prevent selective grazing, so that the animals selected pasture containing 10 to 12% crude protein in the first year and 8 to 10% during the second year. He pointed out that frequency of spraying (weekly), heavy dews, intermittent rainfall during the experimental period, low palatability of mature carpet grass and the high degree and selectivity

by the animals were some of the factors that contributed to the low effect of spraying. He concluded that, for Queensland conditions, more frequent spraying would be uneconomical and impracticable.

Coombe and Tribe (1962) studied the value of spraying urea and molasses on dry, standing forage. It was observed that practically all animals (sheep and cattle) were attracted to pasture treated with molasses. In general, cattle showed a greater preference for sprayed forage than did sheep.

In Uruguay, Christiansen (1965) studied the effect of spraying molasses and urea on a native pasture. The mixture was supplied twice weekly and 1/8 of the total area was sprayed each time until the entire pasture had been sprayed. He found that the palatability of dry coarse grasses Paspalum quadrifarium and Schyzachyrium paniculum was improved and that the animals grazed extensively in the sprayed areas.

In California, Wagnon and Goss (1961) compared a) dry rank forage sprayed with molasses-urea mixture, b) sprayed only with molasses, and c) untreated forage. Weekly application of 14 pounds of molasses or molasses-urea mixture per animal were made. They found that rank, dry forage of low palatability was completely utilized by the animals after spraying with molasses or molasses-urea mixture, however, similar unsprayed forage was mostly left ungrazed. They also reported that there was no loss of the sprayed material until light dews occurred 43 and 63 days after initial spraying. Practically all sprayed mixture was washed from the forage by 0.72 inches of rain that occurred 90 days after the initial treatment.

In another study Tulloh et al. (1963) compared a) molasses fed in a trough, b) standing forage sprayed with urea and molasses, and

c) not supplemented. They reported that all supplemented treatments significantly increased forage intake.

It appears that a sudden change in cattle grazing habits occurs when green forage became available after rain. Coombe and Tribe (1962) reported that if a "green pick" occurred due to unseasonal rains, spraying molasses and urea had no effect on forage intake. They stated that once sufficient rain had stimulated growth of green shoot, the animals preferred to graze the green material rather than concentrate on sprayed areas. On the other hand, Wagnon and Goss (1961) observed that the animals on a sprayed treatment continued to eat the old forage that had been sprayed with molasses-urea mixture, instead of the new regrowth. However, in the same experiment it was observed that animals on the control treatment started to graze the young green plants, rejecting as much as possible the old leached forage.

The preference for molasses sprayed forage appears to vary with the palatability of the mixture sprayed, the rate of molasses, and the weather. Sprayed pastures were strongly preferred by grazing animals, however, preference was not evident 24 hours after spraying. O'Bryan (1960) observed that the preference for the sprayed forage was maintained for two days and Mostert (1959) reported that the sprayed area should be grazed off within 3 to 4 days.

In studies of different spraying densities, Bishop (1959) compared three rates of a mixture molasses-urea: a) one gallon per 10 to 15 square yards, b) one gallon per 50 square yards, and c) one gallon per 100 square yards. Spraying at the rate of one gallon to 50 square

yards was found to give the best results. At a density of one gallon per 100 square yards much of the grass remained ungrazed, so that the mixture absorbed by this ungrazed grass was merely wasted. Densities of one gallon to 10 to 15 square yards were found to be unsuitable because animals then grazed too short. He emphasized that this is particularly undesirable on sandy soils where grass roots can be pulled out easily.

Effect of Grazing Management to Botanical Composition

One of the most important factors to consider in grazing experiments is the change in botanical composition. The presence of grazing animals has effects upon the pasture through defoliation, excretion, and trampling (Coaldrake et al., 1976). T' Mannetje et al. (1976) stated that even a so called pure stand will usually contain varying amounts of other species and that botanical composition is important because individual species or cultivars vary in feeding value, in content of harmful substances, and in their reaction to environmental and management factors.

Changes in botanical composition as a result of grazing management systems are well documented. Bryan (1970) studied the effects of low and high stocking rates on the botanical composition of mixed pasture. He found that high stocking rate increased Paspalum dilatatum Poir., and total weeds from 24 to 33% and 14 to 22%, respectively, and reduced Chloris gayana Kunth. from 18 to 7%. In this experiment heavily stocked pastures were reduced to a closely clipped lawn while the lightly grazed ones usually carried a considerable bulk of material 0.3 to 1 m high.

In Australia, Cameron and Cannon (1970) observed changes in botanical composition resulting from increased stocking rates of 4.9, 7.4, 9.9, 12.4, 14.8, 17.3, and 19.8 sheep/ha, from 1963 to 1968. Trifolium subterraneum L. during this period increased from 30 to 70% at 4.9 sheep/ha and decreased from 30 to 10% at 19.8 sheep/ha. Lolium perenne L. which in 1963 was the main grass component, representing 20 to 40%; by 1968 declined to a trace at all levels of stocking rates. They also pointed out that the decline of L. perenne was more rapid at high than low stocking rates and that by 1965 it had decreased to less than 10% at 19.8 sheep/ha. Poa annua L. not initially present in any of the pastures, in 1968 ranged from a trace at 7.4 and 9.9 sheep/ha, and to 30% at 17.3 and 19.8 sheep/ha.

Rodel (1970) compared the effect of two stocking rates upon different grasses. He found that high stocking rate caused marked changes in basal cover of the grasses. Chloris gayana Kunth. decreased from 3.8 to 0.7% while Cynodon plectostachyum increased from 3.0 to 11.5%.

Serrao (1976) studied the response of Desmodium intortum (Mill) Urb-'Coastcross-1' bermudagrass mixture to different levels of grazing period, rest period, and grazing pressure. He reported that the grass percentage in the mixture increased with heavy grazing pressure, while the legume percentage increased with long rest periods associated with medium to light grazing pressure.

Ritson et al. (1971) studied the changes in botanical composition of a mixture of Townsville stylo (Stylosanthes humilis H.B.K.), perennial grasses, and annual grasses at two stocking rates, namely 1 cow per 1.2 and 2.4 hectare. They found that stocking rate

significantly influenced the botanical composition of the mixture. With a stocking rate of 1 cow per 2.4 hectare the pasture was dominated by perennial grasses. At a stocking rate of 1 cow per 1.2 hectare the pasture became dominated by Townsville stylo and annual grasses.

Campbell and Beale (1973) studied the botanical composition of natural pastures stocked at 2.5, 3.7, and 4.9 sheep/ha. Higher stocking rates resulted in a lower contribution by barley grass (Hordeum leporinum Link.) to the pasture, but an increased contribution by silver grass (Vulpia myuros K. Gmel.) and naturalized medics (Medicago spp.).

Johnston et al. (1971), in a long-term grazing experiment conducted over a 17-year period, compared light, moderate, heavy, and very heavy stocking rates on the botanical composition of a fescue grassland range. Percent basal area of vegetation in lightly grazed plots changed from dominance by Danthonia parryi Scribn. to dominance by Festuca scabrella Torr. F. scabrella was largely eliminated by very heavy grazing and the plots were invaded by various species, including Taraxacum officinale Weber. Populus tremuloids Michx. encroached upon grassland in the lightly and moderately grazed treatment but the same was prevented in the heavily and very heavily grazed pastures.

Pearson and Whitaker (1974) presented changes in botanical composition by cattle grazing yearlong at light, moderate or heavy stocking rates. The most abundant grasses in the pasture were slender bluestem (Andropogon tener (Ness) Kunth.), pinehill bluestem (A. divergens (Hack.) Anderss. ex Hitchc.), panicums (Panicum spp.), and paspalums (Paspalum

spp.) They reported that although overall herbage composition was not changed, grazing intensity did affect individual species. Pinehill bluestem, the principal specie on the range declined from 57% under light grazing to 17% under heavy grazing. Carpetgrass was 1 and 26% under light and heavy grazing, respectively.

In Nebraska, McCarty et al. (1974) studied the effect of rotational and continuous grazing upon change in botanical composition of a pasture, from 1946 to 1969. They reported that under rotational grazing, relatively few weeds invaded the pastures and only a small amount of blue grama (Bouteloua gracilis [H.B.H.] Lag. ex Stend) and sand lovegrass (Eragrostis trichodes [Nutt.] Wood) persisted. In 1969, the mixture consisted primarily of big bluestem (Andropogon gerardi Vitman), indiangrass (Sorghastrum nutans [L.] Nash) and switchgrass (Panicum virgatum L.). In the continuously grazed warm season grass plots the main desirable specie was blue grama.

Ottosen et al. (1975) studied the change in botanical composition of a mixture of tropical grass-legume pasture by comparing strip and continuous grazing. Both grazing management systems caused marked changes in botanical composition of the pasture. Legumes decreased from 24 to 16% in the strip grazed plots while that in the continuously grazed treatment, the legumes increased to 38%. They emphasized that after the experiment, both grasses and legumes regrew without any differences resulting from the previous grazing systems.

MATERIALS AND METHODS

General Description

A grazing experiment was conducted from April to November 1976 at the Beef Research Unit which is located approximately 21 kilometers northeast of Gainesville, Florida.

The soil at the experimental site is underlain by limestone of the Ecocene age having an overlay of acid, sandy, and loamy marine sediments (U.S.D.A., 1954). These Myakka fine sand soils are somewhat poorly drained and contain a spodic horizon (organic hardpan) which is an accumulation or organic matter, iron, and aluminum (Carlisle and Pritchett, 1971). This hardpan increases the severity of both wet and dry periods by retarding the vertical movement of water to and from lower levels. Data reported by Koger et al. (1961) shows that the average organic matter content of this soil is 2.25%. The average pH is 4.9, varying from 4.5 to 5.2, depending on the percentage of organic matter.

The predominant native vegetation on the experimental site consisted mainly of longleaf pine (Pinus australis Michx. f.), wiregrass (Aristida spp. and Sporobolus spp.), saw palmetto (Serenoa repens Bartr. Small), gallberry (Ilex glaba L.), runner oak (Quercus minima Sarg.), and cypress (Taxodium asendens Brongn.)

The climate is subtropical and humid, with a frost-free season averaging 276 days and an average annual precipitation of 1,300 mm

U.S.D.A., 1954). Table 1 presents mean monthly maximum and minimum temperatures and rainfall during 1976 at the Beef Research Unit. For 1976, total rainfall was recorded to be 1,312 mm.

Table 1. Monthly mean maximum and minimum temperatures and rainfall at the Beef Research Unit for 1976.

Month	Temperature		Rainfall	
	Max	Min.	1976	Normal†
	----- °C ------		------- mm --------	
January	18.3	1.8	53	65
February	23.7	5.5	34	82
March	27.2	10.7	46	103
April	27.7	11.0	77	93
May	29.6	15.5	141	87
June	31.5	18.5	215	166
July	34.4	20.4	51	187
August	33.3	19.9	100	192
September	31.2	19.0	231	124
October	26.0	10.8	55	106
November	20.8	5.5	56	44
December	18.1	4.1	126	63

† Average precipitation for Gainesville (Fla.) from 1931 to 1960.

Experimental Pasture

The experiment was conducted in a pasture of bahiagrass (Paspalum notatum Flugge), smutgrass (Sporobolus poiretii [Roem. and Schult.]

Hitchc.), and white clover (Trifolium repens L.) appearing in the spring. This pasture was selected because the smutgrass infestation is typical of many pastures in Florida. The initial ground cover was between 40 and 50% smutgrass. Bahiagrass was the predominant desirable specie. This area had previously been grazed as one pasture for several years and mowed annually late in the fall.

Treatments

The main treatments in this experiment consisted of

1. Control
2. Molasses sprayed on the pasture to increase palatability of the smutgrass.
3. Dalapon applied in the spring followed by mowing and N fertilization.

In addition to the three main treatments presented above, eight extra treatments were included, making a total of 11 treatments. The eight extra treatments included the following:

4. Dalapon applied in the spring followed by burning and N fertilization.
5. Dalapon applied in the fall followed by burning and N fertilization.
6. Dalapon applied in the fall followed by mowing and N fertilization.
7. Ground Hawg[†] in the spring.
8. Ground Hawg in the spring followed by N fertilization.

[†] A rototiller-type cultivator.

9. Ground Hawg in the spring followed by seeding of bahiagrass and N fertilization.
10. Ground Hawg in the fall followed by seeding annual ryegrass (Lolium multiflorum Lam.) and N fertilization.
11. Burning in the fall and dalapon applied in the spring followed by mowing and N fertilization.

Grazing Management Factors

Within the first 3 main treatments listed above, length of rotation cycle (grazing period and rest period combined), and grazing pressure were also experimental variables. Each factor was studied at 5 levels. Length of rotation cycle was expressed in days and grazing pressure was defined as residual dry matter in metric tons/ha left after grazing. The combinations of rotation cycle and grazing pressure, each at 5 levels, were arranged in a response surface type of experiment.

The factors studied with their respective levels are presented in Table 2. A range of plus or minus 0.2 metric tons/ha was established for the projected residual dry matter left after grazing. Grazing periods lasted from 1 to 4 days for all treatments and were included in the number of days in the rotation cycle. In the continuously grazed pastures the animals were not maintained in the pastures continuously. In an effort to simulate continuous grazing, animals were moved in and out of the pastures every few days to achieve the projected level of residual dry matter.

Table 2. Levels of length of rotation cycle and grazing pressure.

Length of rotation cycle	Grazing pressure[†] projected RDM
-------days-------	-metric tons/ha-
0[ǂ]	0.5±0.2
14	1.3±0.2
28	2.1±0.2
42	2.9±0.2
56	3.7±0.2

[†]Residual dry matter left after grazing.

[ǂ]Continuous grazing simulated.

Experimental Design

The experimental design used was a modified central composite in 2 factors (rotation cycle and grazing pressure) each at 5 levels arranged in a Response Surface Design (Fig. 1).

Combinations of length of rotation cycle and grazing pressure were superimposed upon each of the first 3 main treatments. The combinations of the 5 levels of each factor made up thirteen different grazing management combinations or design points. The arrangement of the thirteen combinations consisted of 4 factorial, 4 axial, 1 center, and 4 corner points (Table 3). The factorial points were not replicated. However, the axial, center, and corner points were replicated twice. making a total of 22 pastures (experimental units) per main treatment.

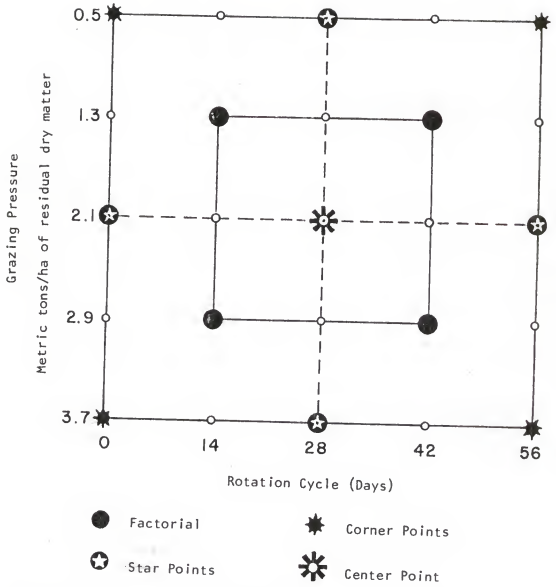


Figure 1. Response surface design in two factors - 13 combinations.

Table 3. Combinations of rotation cycle and grazing pressure of the Central Composite Design.

Length of rotation cycle	Grazing pressure projected RDM†	Points	Number of replications
-----days-----	-metric tons/ha-		
42	2.9	Factorial	1
42	1.3		
14	2.9		
14	1.3		
28	3.7	Axial	2
28	0.5		
56	2.1		
0*	2.1		
28	2.1	Central	2
56	3.7	Corner	2
56	0.5		
0*	3.7		
0*	0.5		

† Residual dry matter left after grazing.

* Continuous grazing simulated

In this study, the central treatment (center point) was the combination of a length of rotation cycle of 28 days and a grazing pressure equal to 2.1 metric tons/ha of residual dry matter left after grazing. The central treatment was the combination of rest period and grazing pressure imposed upon the 8 extra treatments, each replicated twice. There were a total of 82 combinations of treatments and grazing managements and they were assigned to the pastures units completely at random.

Construction of Physical Facilities

The experimental area was selected in December 1975 on the basis of uniform smutgrass ground cover. In early January 1976, 4.1 hectares were allocated to the experiment and surveyed for the location of the fence lines. The area was subdivided into 82 pastures (Fig. 2), 50 m in length and 10 m in width (500 m^2). Five-strand barbed wire line fences and electric division fences were built. A water supply system was installed underground using 1" plastic pipe with risers along the fence to provide water for the animals. Mineral boxes and water containers were provided. The water level was controlled in each container by a float valve.

Experimental Analysis

From May to July, 36 Brown Swiss-Angus heifers and cows (cows with calves until August, when the calves were weaned), with an average weight of 351 kg were used to graze the experimental pastures.

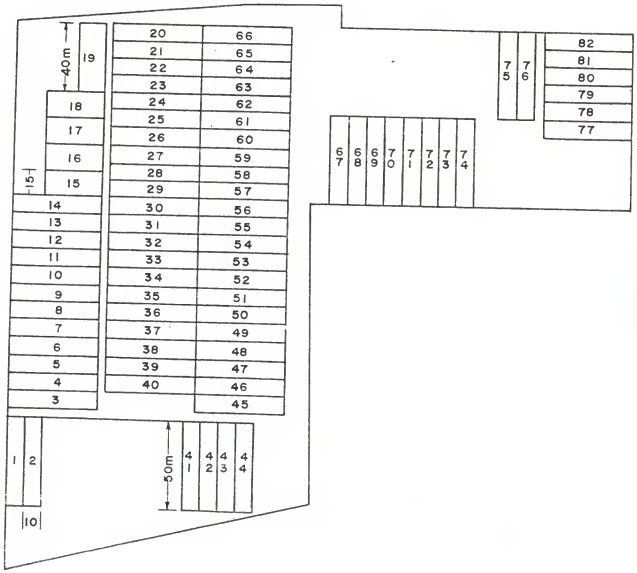


Figure 2. Field layout of the experimental pastures.

in August, due a higher forage production, the number of animals was increased to 50.

The put-and-take technique was used to stock the pastures to the desirable grazing pressure levels. When needed, the animals were assigned at random to graze the pastures. The animals were weighed every 28 days in order to estimate the stocking rate.

From 20 September through the conclusion of the experiment, all animals were supplemented with molasses at an average rate of 2.2 kg/animal/day. A complete mineral mixture was made available free-choice throughout the study.

On 12 December 1976, all experimental pastures were fertilized with 14.8 kg of P and 55.8 kg of K/ha.

Treatment Application

Main Treatment 1. Control

On the control treatments, only different grazing management systems were imposed.

Main Treatment 2. Molasses Sprayed on the Pastures

On the rotationally grazed pastures, molasses was sprayed on the standing forage before each grazing period to increase the palatability of the smutgrass. In the continuously grazed treatments, molasses was sprayed at 2-week intervals. In each molasses treatment it was applied immediately prior to introducing the animals to the pastures.

Molasses was diluted in equal parts of water and sprayed on the pastures at the rate of 320 liters/ha. Molasses before diluting with water weighed 1.34 kg/liters. Spraying was carried out with a tractor

mounted, boomless sprayer. A spray pump was operated at 2.5 kg/cm^2 pressure and driven at 4 km/hour.

Main Treatment 3. Dalapon Applied in the Spring Followed by Mowing and N Fertilization

On 28 April, when the smutgrass plants were growing quite vigorously, dalapon (2,2-dichloropropionic acid) at the rate of 5.6 kg/ha was sprayed on the pastures. It was applied in water at 277 liters/ha with a tractor-mounted sprayer. On 19 May, three weeks after the dalapon application, all pastures were mowed to a height of 6 to 7 cm with flail mower. On 7 June, 56 kg N/ha was applied using a Gandy fertilizer spreader. Ammonium sulfate (21% N) was used as the source of N.

Dalapon Applied in the Spring Followed by Burning and N Fertilization

Dalapon at the rate of 5.6 kg/ha was applied to the pastures on 28 April, 1976. On 1 June, the top kill of smutgrass plants became evident due to the application of dalapon. The pastures were then burned. One week later the pastures were fertilized with 56 kg N/ha as ammonium sulfate.

Dalapon Applied in the Fall Followed by Burning and N Fertilization

The fall application of dalapon was completed on 4 October, when the smutgrass was still actively growing. The rate and method of application was the same as used for the spring treatment (5.6 kg/ha). The pastures were burned on 15 February 1977.

Dalapon Applied in the Fall Followed by Mowing and N Fertilization

In this treatment, dalapon (5.6 kg/ha) application was carried out on 4 October 1976. The pastures were mowed to a 6 to 7-cm stubble on 10 January 1977.

Ground Hawg in the Spring

On 6 May, the Ground Hawg was used to till the pastures. Depth of cultivation was 12 to 13 cm below the soil surface. The cutting blades broke up and lossened the surface soil and destroyed the shallow rooted plants. This operation usually destroys the canopy and re-seeding is necessary unless a good supply of viable seed exists in the soil.

Ground Hawg in the Spring Followed by N Fertilization

On 6 May, the Ground Hawg was passed over the pastures. On 5 June, 56 kg/ha of N fertilizer was applied as ammonium sulfate.

Ground Hawg in the Spring Followed by Seeding of Bahiagrass and N Fertilization

The tillage operation with Ground Hawg was carried out on 6 May. On the following day bahiagrass, at the rate of 16 kg/ha, was sown, covered and packed with a cultipacker seeder. One month later a N application at the rate of 56 kg N/ha was made using a Gandy fertilizer spreader. Due to high temperatures and lack of sufficient rain, a poor stand resulted from this seeding. Bahiagrass was seeded again on 10 August at the same rate, after tilling the soil again with the Ground Hawg.

Ground Hawg in the Fall Followed by Seeding of Ryegrass and N Fertilization.

On 8 October, Ground Hawg tillage operation was carried out. On the following day 'Tetrablend' ryegrass was seeded at the rate of 16 kg/ha. One month later the pastures were fertilized with 56 kg N/ha. Pastures seeded to ryegrass in early October were fully sodded by mid-December of 1976.

Burning in the Fall and Dalapon Applied in the Spring Followed by Mowing and N Fertilization

Burning was carried out later than anticipated due to heavy rainfall during the fall season.

Measurements

Smutgrass Ground Cover

In order to study the effect of the treatments on the change of smutgrass ground cover, 4 non-randomly selected 1 m^2 permanent quadrats were set up in each pasture. The area for each quadrat was chosen in such a way that all quadrats contained similar smutgrass ground cover before starting the experiment. A wooden stake was driven in each of 2 predetermined corners of the quadrat.

The equipment used to determine the smutgrass ground cover consisted of a 2.0 m x 0.5 m (1 m^2) frame constructed of aluminum (Fig. 3). It was subdivided by thin aluminum bars in order to give 100 equal squares each 10 cm x 10 cm, to facilitate the estimation of plant ground cover. The frame was supported above the canopy by four legs, each equipped with a lock screw which allowed the height of the frame to vary from 20 to 30 cm above the ground.

The quadrat charting method was used to evaluate the change in smutgrass ground cover. Ground cover was estimated in early April before applying the treatments and again late in October 1976. The frame was placed over each permanent quadrat and outlines of smutgrass clumps were drawn on acetate transparent sheets (Fig. 4) at a scale of 1 mm on the transparency to 10 mm on the frame. Later, areas

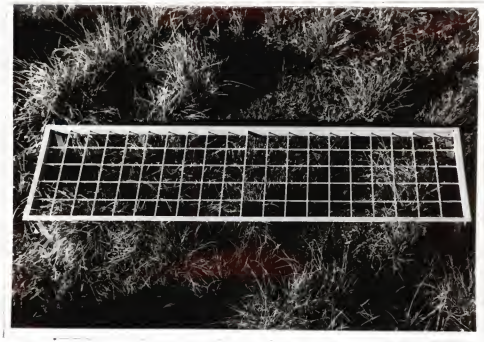


Fig. 3. The 1 m^2 frame used to determine the smutgrass ground cover.

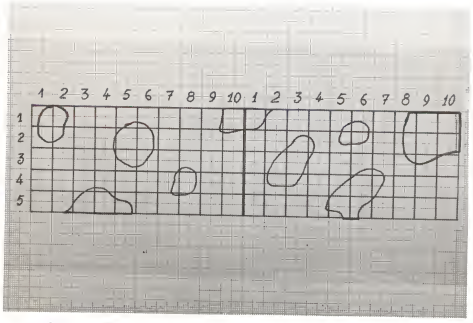


Fig. 4. Outlines of smutgrass clumps on acetate transparent sheets.

outlined on the transparency were inked (Fig. 5) with india ink and the areas were determined, by passing the transparency through an electronic leaf area meter.

The change in ground cover of smutgrass for each pasture was determined by the difference between the ground cover estimates made in October and April 1976, and are expressed as percentage units of change.

Dry Matter Determination After Grazing

Residual dry matter/ha was estimated after each grazing period on the rotationally grazed pastures. On the continuously grazed pasture residual dry matter was estimated every 28 days. All estimates were made by a double sampling procedure, using a Neal Electronic Model 18-200 Herbage Meter (Fig. 6).

In this procedure the capacitance meter was first adjusted to zero, with the probes standing on bare soil in the field where measurements were to be made. The instrument was then taken to the pasture for sampling. Twenty random readings were taken in each pasture. From these twenty, 4 were randomly selected to be cut. A metal frame measuring 0.186 m^2 (2 sq. ft.), which fit around the probes, was placed in position. The capacitance meter was then removed and the forage within the frame was cut to ground level using a grass clipper. The forage cut was gathered into a paper bag and oven-dried at 70^{o} C for 24 hours and weighed.

The capacitance meter readings and dry weight yields/0.186 m^2 were used as independent and dependent variables respectively, in a regression model forced through the origin. The regression coefficient was obtained from the equation:

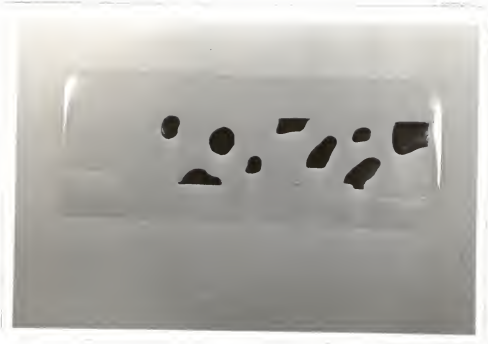


Fig. 5. Black circular areas represent the outlines of smutgrass clumps after having been inked.

Fig. 6. View of the capacitance meter used in the double-sampling procedure.

$$\hat{Y} = b\ X$$

where:

$\hat{Y}$ = estimated dry matter, metric tons/ha

b = regression coefficient of capacitance meter reading on dry matter yield of harvested samples.

X = value of capacitance meter reading.

The forage dry matter left after each grazing period was estimated by the following formula:

$$RDMA = \frac{\overline{Y} + b\ \overline{X}}{2}$$

where:

RDMA = residual dry matter adjusted

$\overline{Y}$ = mean dry matter of the harvested samples (4 samples/pasture/rotation cycle)

b = regression coefficient

$\overline{X}$ = mean of the capacitance meter reading of the unharvested samples (16 readings/pasture/rotation cycle).

Parameters Measured

The response of the pasture to the main treatments and grazing management was measured in terms of the following response variables:

1. Change in smutgrass ground cover expressed as percentage units
2. Stocking rate
   a. Animals/ha/day
   b. Liveweight/ha/day

For each main treatment the response variables were fitted using a second order polynomial of the type:

$$\hat{Y} = b_o + b_1X_1 + b_2X_2 + b_{11}X_1^2 + b_{22}X_x^2 + b_{12}X_1X_2$$

where:

$\hat{Y}$ = estimated response

X_1 = length of rotation cycle (days)

X_2 = grazing pressure (metric tons/ha of RDMA)

b_o = intercept

b_i = linear regression coefficient

b_{ii} = quadratic regression coefficient

b_{ij} = regression coefficient of the interaction

The following analysis of variance was performed in order to test the fit of the model:

Analysis of Variance

Source of Variance	df	MS	F
Total	21		
Due to regression	5		
RC	1		
GP	1		
RC x RC	1		
GP x GP	1		
RC x GP	1		
Residual	16		
Lack of fit	7		
Error	9		

The estimation of the error was generated from the sums of squares of the nine replications of the axial, center, and corner points. The lack of fit sum of squares was calculated by difference, subtracting the error sum of square from the residual sum of square.

The statistical analysis was done using the function GLM of the Statistical Analysis System (Barr et al., 1976) and the APL function was used to locate the stationary point.

RESULTS AND DISCUSSION

Results and discussion will be presented only for the control and sprayed molasses treatments. The spring applied dalapon retarded and/or killed both the smutgrass and the bahiagrass to such an extent that regrowth of bahiagrass was not enough to allow grazing during the 1976 growing season. Treatments 3 through 11 (see page 35) were grazed from time to time but no data were collected during the first year of this multiyear study.

The following notations will be used on the presentation of the results and discussion.

RDM = projected residual dry matter

RDMH = residual dry matter based on harvested samples only

RDMA = residual dry matter adjusted to forage meter readings

Residual Dry Matter

Control Treatment

Projected residual dry matters (RDM) left after grazing by combination of rotation cycle and grazing pressure on the control treatment are presented in Table 4. Also, included in the table are the seasonal averages of residual dry matters based on harvested samples (RDMH) and residual dry matters based on the harvested samples and adjusted to meter readings (RDMA).

Table 4. Residual dry matter left after grazing for different combinations of length of rotation cycle and grazing pressure on the control treatment.

Combinations		RDMH			RDMA				
RC	Projected RDM	$\bar{X}$	SD_M	CV	$\bar{X}$	SD_R	b	CV	r
days	--------metric tons/ha-------			%	-metric tons/ha-			%	
56	0.5±0.2	.785	.221	29	.716	.147	.050	19	.84
56	0.5±0.2	.838	.301	36	.837	.204	.047	24	.90
42	2.9±0.2	2.893	.660	23	2.841	.362	.049	12	.87
14	1.3±0.2	1.390	.447	32	1.339	.283	.045	20	.81
28	0.5±0.2	.733	.220	30	.743	.139	.051	19	.81
28	0.5±0.2	.748	.356	47	.739	.126	.049	17	.94
0	3.7±0.2	3.594	.871	24	3.579	.419	.046	12	.90
0	3.7±0.2	3.577	1.053	29	3.722	.480	.046	13	.91
0	2.1±0.2	2.193	.801	36	2.088	.377	.045	17	.88
0	2.1±0.2	2.258	.778	34	2.449	.460	.046	20	.82
14	2.9±0.2	3.101	.840	27	3.059	.449	.045	14	.86
56	3.7±0.2	3.727	.712	19	3.419	.411	.046	11	.92
56	3.7±0.2	3.628	.862	24	3.665	.315	.047	9	.93
42	1.3±0.2	1.436	.519	36	1.437	.260	.043	18	.91
28	3.7±0.2	3.769	1.008	26	3.729	.455	.047	12	.90
28	3.7±0.2	3.652	1.086	29	3.795	.376	.047	10	.94
28	2.1±0.2	2.135	.697	33	2.125	.331	.048	15	.88
28	2.1±0.2	2.221	.789	35	2.205	.290	.048	13	.93
0	0.5±0.2	.783	.282	36	.789	.144	.050	18	.88
0	0.5±0.2	.779	.259	33	.813	.149	.045	19	.88
56	2.1±0.2	2.135	.819	38	2.092	.250	.046	12	.95
56	2.1±0.2	2.212	.804	36	2.072	.392	.042	18	.95

RC = Rotation cycle

$\bar{X}$ = mean

SD_M = Standard deviation from mean

SD_R = Standard deviation from regression

The estimated RDMH in almost all combinations of rotation cycle and grazing pressure were within the range of projected residual dry matter/ha. The values of the RDMH ranged from 0.733 to 3.769 metric tons/ha. Residues greater than those projected occurred in all combinations in which grazing pressure was projected at 0.5 metric tons/ha of residual dry matter left after grazing. The relative high residues in this case may have been due in part to high dung spot concentration on the pastures as a consequence of the heavy stocking rate required to have a residue of 0.5 metric tons/ha. This observation is in agreement with Greenhalgh and Reid (1969), who indicated that fouling of less than 3% of the surface of a ryegrass pasture with dung resulted in over 20% rejection at a heavy grazing intensity.

The coefficients of variation for RDMH ranged from 19 to 47%. The coefficients of variation increased with decreasing amount of residue left after grazing (Table 4). This is apparently due to the lower mean value for the residual dry matter and the very low variation in the standard deviation among the different levels of grazing pressure.

Residual dry matter based on harvested samples and adjusted to meter readings (RDMA) tended to be lower than the RDMH. The RDMA ranged from 0.716 to 3.795 metric tons/ha. The data show that like RDMH, the values of RDMA for grazing pressure equal to 0.5 metric tons/ha of residue, are also outside of the projected ranges (RDM).

The regression coefficients (b) were always positive and varied from 0.043 to 0.051 metric tons/ha per unit of forage meter reading. Although the regression coefficients were similar, heavier grazing pressure tended to give larger regression coefficients.

The standard deviations of the regression of RDMA ranged from 0.144 to 0.480 metric tons/ha. It may be noted that larger standard deviations from regression occurred at lighter grazing pressures (high RDM) than at heavier grazing pressures. The lower standard deviations from regression observed at heavier grazing pressures were probably due to a lower residual dry matter yield (RDMA).

All correlation coefficients (r) were highly significant ($P<0.01$), ranging from 0.81 to 0.95 (Table 4). However, the correlation coefficients were generally slightly lower at heavier grazing pressures.

The most noticeable effect of adjusting the harvested sample to meter reading was to reduce the coefficients of variation. The coefficients of variation of RDMA ranged from 9 to 24%, which means a decrease in sample variation of about 40% when compared to the variation of the RDMH.

Molasses Sprayed Treatment

Table 5 presents the seasonal average residual dry matters left after grazing by combinations of rotation cycle and grazing pressure on the molasses sprayed treatment.

As in the case for control treatment, most of the RDMH were within the range of projected residual dry matter/ha (RDM/ha). They ranged from 0.734 to 3.931 metric tons/ha. However, exceptions occurred for all grazing management systems with 0.5 metric tons/ha of residual dry matter, which were greater than the projected RDM left after grazing. Similarly to the control treatment, the high frequency of dung spots on the pastures seems to have had an effect upon the amount of RDM left.

Table 5. Residual dry matter left after grazing for different combinations of length of rotation cycle and grazing pressure on the molasses sprayed treatment.

Combinations		RDMH			RDMA				
RC	Projected RDM	X	SD_M	CV	X	SD_R	b	CV	r
days	-----metric tons/ha-------			%	--metric tons/ha-			%	
56	0.5±0.2	.762	.255	33	.803	.137	.051	18	.89
56	0.5±0.2	.853	.338	40	.814	.149	.043	17	.95
42	2.9±0.2	3.164	1.066	34	2.970	.770	.048	24	.74
14	1.3±0.2	1.367	.469	34	1.282	.239	.043	17	.89
28	0.5±0.2	.734	.228	31	.712	.162	.047	22	.82
28	0.5±0.2	.750	.220	29	.747	.103	.048	14	.88
0	3.7±0.2	3.931	1.012	25	3.915	.291	.047	7	.96
0	3.7±0.2	3.841	.970	25	3.819	.378	.046	10	.92
0	2.1±0.2	2.123	.811	38	2.196	.553	.048	26	.75
0	2.1±0.2	2.110	.623	29	2.136	.299	.045	14	.88
14	2.9±0.2	3.057	1.021	33	2.988	.564	.050	18	.83
56	3.7±0.2	3.722	1.038	28	3.692	.282	.046	7	.97
56	3.7±0.2	3.902	.737	19	3.851	.338	.047	8	.93
42	1.3±0.2	1.240	.491	39	1.233	.251	.045	20	.86
28	3.7±0.2	3.726	.977	26	3.732	.384	.046	10	.92
28	3.7±0.2	3.664	.723	20	3.516	.549	.045	15	.77
28	2.1±0.2	2.151	.743	34	2.194	.300	.047	14	.92
28	2.1±0.2	2.283	.861	38	2.274	.518	.046	23	.80
0	0.5±0.2	.926	.336	36	.932	.197	.040	21	.88
0	0.5±0.2	.815	.325	39	.804	.178	.049	22	.93
56	2.1±0.2	2.094	.815	39	2.033	.279	.048	13	.14
56	2.1±0.2	2.031	.904	44	1.997	.183	.050	9	.98

RC = Rotation cycle.

$\overline{X}$ = Mean.

SD_M = Standard deviation from mean.

SD_R = Standard deviation from regression.

The coefficients of variation for RDMH are also given in Table 5. They varied from 19 to 44%, and were higher for heavier grazing pressure (low RDM).

For most of the combinations of rotation cycle and grazing pressures, RDMA were slightly lower than the RDMH.

The regression coefficients ranged from 0.040 to 0.051. As in the control treatment, heavier grazing pressures tended to result in larger regression coefficients. The standard deviation of the regressions of RDMA ranged from 0.137 to 0.770, and tended to decrease with heavier grazing pressures (low RDM).

In all combinations of rotation cycle and grazing pressure the correlation coefficients of meter reading on residual dry matter were highly significant ($P<0.01$) and ranged from 0.74 to 0.98. Lower correlation coefficients for heavier grazing pressures were evident (Table 5).

Changes in Smutgrass Ground Cover

Control Treatment

Changes in smutgrass ground cover for the different combinations of length of rotation cycle and grazing pressure from April to October 1976, are given in Table 6. In the control treatment, the change in smutgrass ground cover ranged from -22.2 to 33.8 percentage units.

The main effects of grazing pressure and length of rotation cycle on the change in smutgrass ground cover are presented in Tables 7 and 8, respectively. Changes in smutgrass ground cover indicated an increase ($P<0.05$) with decreasing grazing pressure (low RDM). On the

Table 6. Observed change in smutgrass ground cover for the different combinations of length of rotation cycle and grazing pressure on the control treatment, from April to October 1976

Length of rotation cycle	Grazing pressure RDMA†	Observed change in smutgrass ground cover
------days-------	-metric tons/ha-	-percentage units-
56	0.771	2.8
56	0.837	9.1
42	2.841	3.8
14	1.339	4.6
28	0.743	5.0
28	0.738	-22.2
0	3.579	33.8
0	3.722	11.7
0	2.088	12.2
0	2.449	- 3.4
14	3.059	- 4.2
56	3.419	15.6
56	3.665	27.4
42	1.437	21.7
28	3.729	20.8
28	3.795	5.1
28	2.125	4.9
28	2.206	16.3
0	0.789	- 4.9
0	0.814	- 0.2
56	2.092	- 6.6
56	2.073	- 6.1

† Residual dry matter adjusted.

Table 7. Main effect of grazing pressure on the change in smutgrass ground cover on the control treatment.

Grazing pressure RDM†	Observed change in smutgrass ground cover
-metric tons/ha	---percentage units---
0.5	- 1.8
1.3	8.8
2.1	12.7
2.9	- 0.2
3.7	19.1

† Projected residual dry matter.

Table 8. Main effect of rotation cycle on the change in smutgrass ground cover on control treatment.

Length of rotation cycle	Observed change in smutgrass ground cover
-------days-------	---percentage units---
0	8.2
14	0.1
28	4.9
42	8.5
56	7.0

other hand, changes in smutgrass ground cover were not influenced by the length of the rotation cycle.

The fitted equation for change in smutgrass ground cover on control treatment is presented in Table 9. It shows a significant ($P<0.05$) linear response in change of smutgrass ground cover as a result of changes in grazing pressure. The other terms of the equation were not significant.

The calculated stationary point for change in smutgrass ground cover on the control treatment was found to be located at 11 days for length of rotation cycle and 0.3 metric tons/ha for the adjusted residual dry matter, with a response at this point of -2.4 percentage units (Table 10). The stationary point is outside of the experimental area with relation to grazing pressure, since the heaviest grazing pressure studied was 0.5 metric tons/ha. However, the response at the stationary point (-2.4 percentage units) is between the minimum and maximum values found for change in smutgrass ground cover for control treatment (Table 6).

The contours of predicted change in smutgrass ground cover on the control treatment are presented in Fig. 7. It can be seen from Fig. 7 that smutgrass ground cover decreases with heavier grazing pressures (low RDM). It is evident from the contours that very small changes in smutgrass ground cover occur due to the effect of length of the rotation cycle. The contours emphasize the importance of grazing pressure since there is little effect due to length of rotation cycle on smutgrass ground cover.

Table 9. Fitted equations for treatment and response variables.

CONTROL	Smutgrass Ground Cover:	$\hat{Y} = -1.9937 - 0.0544RC - 0.5837GP^{*} + 0.0030RC^{2} + 1.6623GP^{2} - 0.0387(RC \times GP)$
	Animal/ha/day:	$\hat{Y} = 34.6825 + 0.0259RC - 17.7108GP^{**} - 0.0001RC^{2} + 2.7770GP^{2**} - 0.0023(RC \times GP)$
	Liveweight/ha/day:	$\hat{Y} = 11.2713 - 0.0026RC - 5.3759GP^{**} - 0.0002RC^{2} + 0.7889GP^{2**} + 0.0026(RC \times GP)$
MOLASSES	Smutgrass Ground Cover:	$\hat{Y} = -8.0526 - 0.0462RC - 1.5740GP^{**} + 0.0064RC^{2} + 2.1983GP^{2} - 0.0418(RC \times GP)$
	Animal/ha/day:	$\hat{Y} = 29.5285 - 0.1764RC - 10.9369GP^{**} + 0.0001RC^{2} + 1.1854GP^{2} + 0.0488(RC \times GP)$
	Liveweight/ha/day:	$\hat{Y} = 10.0563 - 0.0538RC - 3.7655GP^{**} - 0.0001RC^{2} + 0.4112GP^{2} + 0.0168(RC \times GP)$

RC - Rotation cycle-days.

GP - Grazing pressure-metric tons/ha of residual dry matter.

* - ($P<0.05$)

** - ($P<0.01$)

Table 10. Values of the stationary point for treatment and response variables.

Treatment	Smutgrass Ground Cover			Animals/ha/day			Liveweight/ha/day		
	RC	GP	Response†	RC	GP	Response‡	RC	GP	Response
Control	11	0.3	-2.4	10	3.2	6.5	31	3.3	2.2
Molasses	5	0.4	-8.5	60	3.4	5.4	42	3.7	1.9

RC - Rotation cycle-days

GP - Grazing pressure-metric tons/ha of residual dry matter.

† - Change in smutgrass ground cover-percentage units.

‡ - Animals per hectare day.

ƒ - Liveweight per hectare day-metric tons per hectare.

Fig. 7. Contours of change in smutgrass ground cover (percentage units) on the control treatment.

$\hat{Y} = -1.9937 - 0.0544RC - 0.5837GP^* + 0.0030RC^2 + 1.6623GP^2 - 0.0387(RC \times GP)$
15
10
5
0
GRRZ. PRES. (TONS/HA ROMA)
0.50
1.30
2.10
2.90
3.70
4.50
0.00
7.00
14.00
21.00
28.00
35.00
42.00
49.00
56.00
RAT. CYCLE (DAYS)

A general effect of increasing the grazing pressure (low RDM) was to reduce in smutgrass ground cover in the pasture. The results obtained in this experiment indicate that heavy grazing pressures are needed to control smutgrass. Similar results were reported by Campbell and Beale (1973), who reported that increased grazing pressure throughout the growing season reduced the proportion of barley grass in the pasture. In this study it was observed that smutgrass was more attractive to animals in its early growth stages than in later stages, especially after flowering. This was consistent with the findings of Riewe et al. (1975b) who reported that grazing preference for smutgrass was higher during early spring than after May.

Molasses Sprayed Treatment

Table 11 presents the changes in smutgrass ground cover for the different combinations of length of rotation cycle and grazing pressure on the molasses sprayed treatment, from April to October. The change in smutgrass ground cover varied from -20.0 to 31.8 percentage units.

The main effects of grazing pressure and length of rotation cycle upon the change in smutgrass ground cover are shown in Tables 12 and 13, respectively. Smutgrass ground cover increased linearly ($P<0.01$) with decreasing grazing pressure (high RDM). It was not affected ($P>0.05$) by the length of rotation cycle but smutgras increased slightly as the length of rotation cycle increased.

Smutgrass ground cover on the sprayed molasses treatment responded ($P<0.01$) to grazing pressure (Table 9). The other terms of the model were not significant ($P>0.05$).

Table 11. Observed change in smutgrass ground cover for the different combinations of rotation cycle and grazing pressure on the molasses sprayed treatment, from April to October 1976.

Length of rotation cycle	Grazing pressure RDMA†	Observed change in smutgrass ground cover
------days-------	-metric tons/ha-	-percentage units-
56	0.803	6.4
56	0.814	6.7
42	2.970	9.2
14	1.282	- 8.2
28	0.712	- 9.3
28	0.747	- 9.8
0	3.915	18.0
0	3.819	9.4
0	2.196	15.8
0	2.136	3.9
14	2.988	- 0.1
56	3.692	31.8
56	3.851	29.3
42	1.233	- 3.7
28	3.732	15.6
28	3.516	12.9
28	2.194	18.9
28	2.274	1.7
0	0.932	-20.0
0	0.804	- 5.5
56	2.033	23.2
56	1.997	- 8.9

† Residual dry matter adjusted.

Table 12. Main effect of grazing pressure on the change in smutgrass ground cover on the ~~control~~ Molasses treatment.

Grazing pressure RDM†	Observed change in smutgrass ground cover
-metric tons/ha-	---percentage units---
0.5	- 5.2
1.3	3.9
2.1	5.8
2.9	3.7
3.7	19.5

† Projected residual dry matter.

Table 13. Main effect of rotation cycle on the change in smutgrass ground cover on sprayed molasses treatment

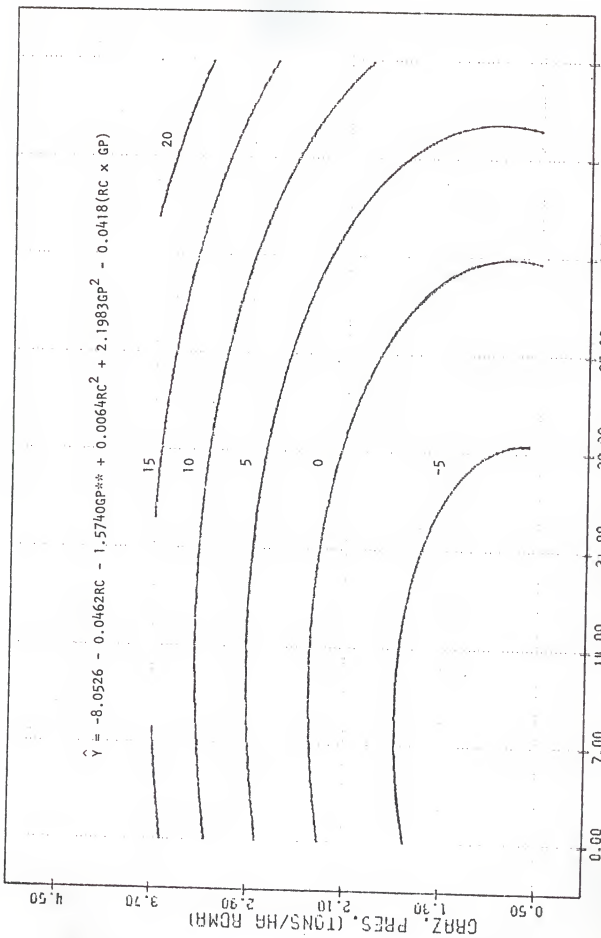
Length of rotation cycle	Observed change in smutgrass ground cover
-------days-------	---percentage units---
0	- 2.7
14	3.6
28	5.0
42	2.5
56	11.4

The stationary point for change in smutgrass ground cover on the molasses sprayed treatment (Table 10) was determined to be at 5 days for rotation cycle and 0.4 metric tons/ha of RDMA. The response at that point was found to be -8.5 percentage units. It can be seen that the stationary point is very close to the experimental region and that the response (-8.5 percentage units) is between the lower and higher values observed for change in smutgrass ground cover (Table 11).

The contours of change in percentage units of smutgrass ground cover on the molasses sprayed treatment are plotted in Fig. 8. It can be observed that significant decreases in smutgrass ground cover may be achieved with heavier grazing pressures. Another trend is that for any level of grazing pressure, smutgrass ground cover increased with an increase in length of rotation cycle. However, a much greater decrease may be attained with heavier grazing pressures than with shorter length of rotation cycle. The contours suggest a fairly rapid reduction in smutgrass ground cover with a combination of heavy grazing pressure and short rotation cycle.

Statistical analysis revealed no differences ($P>0.05$) between the response surfaces for the control and molasses treatments. In this experiment, initially the animals showed a preference for the sprayed pastures; however, the preference did not persist for more than 24 hours. This fact appears to be similar to that reported by O'Bryan (1960) in which the preference for the sprayed pastures did not persist for more than 2 days. The lack of response to the molasses sprayed treatment may have been due to the low rate of molasses used. This observation agrees with those obtained by Bishop (1959) using a similar rate of molasses.

Fig. 8. Contours of change in smutgrass ground cover (percentage units) on the molasses sprayed treatment.


$\hat{Y} = -8.0526 - 0.0462RC - 1.574OGP^{**} + 0.0064RC^2 + 2.1983GP^2 - 0.0418(RC \times GP)$
20
15
10
5
0
-5
GRAZ. PRES. (TONS/HA ADMB)
0.50
1.30
2.10
2.90
3.70
4.50
0.00
7.00
14.00
21.00
28.00
35.00
42.00
49.00
56.00
ROT. CYCLE (DAYS)

Animals/ha/day

Control Treatment

Observed number of animals/ha/day for the different combinations of rotation cycle and grazing pressure on the control treatment are shown in Table 14. Animals/ha/day varied from 4.3 to 28.7.

The main effects of grazing pressure and length of rotation cycle on animals/ha/day are presented in Tables 15 and 16, respectively. Number of animals/ha/day declined linearly ($P<0.01$) with decreasing levels of grazing pressure (increasing RDM). Number of animals/ha/day was not affected by length of rotation cycle.

There was both a linear and quadratic effect ($P<0.01$) of grazing pressure upon the number of animals/ha/day on the control treatment (Table 9 and Fig. 9).

The stationary point was located at 10 days for length of rotation cycle and 3.2 metric tons/ha of RDMA. The response of the stationary point at this combination is equal to 6.5 animals/ha/day. The stationary point in this case is located within the experimental region; however, it is closer to the lower observed values for animals/ha/day (Table 14).

Figure 9 represents the contours of the response of number of animals/ha/day on the control treatment. Under this treatment, number of animals/ha/day increased with increasing grazing pressure (decreasing RDM). At heavier grazing pressure, length of rotation cycle has no effect upon animals/ha/day.

Table 14. Observed animals per hectare per day for the different combinations of length of rotation cycle and grazing pressure on the control treatment.

Length of rotation cycle	Grazing pressure RDMA†	Observed animals/ha/day
-------days------	-metric tons/ha-	
56	0.771	20.1
56	0.837	20.5
42	2.841	7.4
14	1.339	14.6
28	0.743	28.7
28	0.738	23.5
0	3.579	6.6
0	3.722	7.3
0	2.088	9.5
0	2.449	11.2
14	3.059	9.6
56	3.419	5.8
56	3.665	7.1
42	1.437	15.3
28	3.729	4.3
28	3.795	5.5
28	2.125	6.7
28	2.206	7.2
0	0.789	20.7
0	0.814	20.9
56	2.092	6.7
56	2.073	7.9

† Residual dry matter adjusted.

Table 15. Main effect of grazing pressure on animals per hectare per day on the control treatment.

Grazing pressure RDM†	Observed animals/ha/day
-metric tons/ha-	
0.5	22.4
1.3	14.9
2.1	8.2
2.9	8.5
3.7	6.1

† Projected residual dry matter.

Table 16. Main effect of rotation cycle on animals per hectare per day on the control treatment.

Length of rotation cycle	Observed animals/ha/day
-------days-------	
0	12.7
14	12.1
28	12.6
42	11.4
56	11.3

Fig. 9. Contours of animals per hectare per day on the control treatment.

$\hat{Y}$ = 34.6825 + 0.0259RC - 17.7108GP** - 0.0001RC^2 + 2.7770GP^2** - 0.0023(RC x GP)
GRAZ. PRES.(TONS/HA RDMN)
0.50
1.30
2.10
2.90
3.70
4.50
0.00
7.00
14.00
21.00
28.00
35.00
42.00
49.00
56.00
ROT. CYCLE (DAYS)
5
8
11
14
17
20

Molasses Sprayed Treatment

The number of animals/ha/day for the different combinations of length of rotation cycle and grazing pressure on sprayed molasses treatment is presented in Table 17. Animals/ha/day ranged from 3.9 to 22.8. The main effects of grazing pressure and length of rotation cycle on animals/ha/day are listed in Tables 18 and 19, respectively. The number of animals/ha/day declined ($P<0.01$) with decreasing grazing pressure. Number of animals/ha/day was not affected by length of rotation cycle.

The fitted equation (Table 9 and Fig. 10) indicates that there was a quadratic effect ($P<0.01$) upon animals/ha/day due to grazing pressure and that there was no interaction between grazing pressure and length of rotation cycle ($P>0.05$). The number of animals/ha/day was greatly affected only by grazing pressure and there was no response to length of rotation cycle.

The stationary point for animals/ha/day was found to be located at 60 days and 3.4 metric tons/ha of RDMA (Table 10), with a response at this point of 5.8 animals/ha/day. The stationary point is located outside of the experimental region with relation to length of rotation cycle, because 56 days was the longest cycle studied. However, it is well within the experimental region of grazing pressure used in the experiment. The response at the stationary point is within the observed values for the different combinations of grazing pressure and length of rotation cycle (Table 17).

The contours of predicted number of animals/ha/day on the molasses sprayed treatment are presented in Fig. 10. The contours show that

Table 17. Observed animals per hectare per day for the different combinations of rotation cycle and grazing pressure on the sprayed molasses treatment.

Length of rotation cycle	Grazing pressure RDMA†	Observed animals/ha/day
-------days-------	-metric tons/ha-	
56	0.803	18.0
56	0.814	17.6
42	2.970	7.8
14	1.282	14.9
28	0.712	21.5
28	0.747	22.8
0	3.915	6.2
0	3.819	7.1
0	2.196	8.5
0	2.136	10.1
14	2.988	8.7
56	3.692	6.1
56	3.851	5.2
42	1.233	12.0
28	3.732	3.9
28	3.516	5.1
28	2.194	5.4
28	2.274	6.8
0	0.932	22.3
0	0.804	20.2
56	2.033	10.1
56	1.997	10.3

† Residual dry matter adjusted.

Table 18. Main effect of grazing pressure on animals per hectare per day on the sprayed molasses treatment.

Grazing pressure RDM†	Observed animals/ha/day
-metric tons/ha-	
0.5	20.4
1.3	13.5
2.1	8.5
2.9	8.3
3.7	5.6

† Projected residual dry matter.

Table 19. Main effect of rotation cycle on animals per hectare per day on the sprayed molasses treatment.

Length of rotation cycle	Observed animals/ha/day
-------days-------	
0	12.4
14	11.8
28	10.9
42	9.9
56	11.2

animals/ha/day increased with combination of heavier grazing pressures and shorter length of rotation cycle. However, Fig. 10 indicates that very small decreases in number of animals/ha/day is obtained however, if we maintain a constant grazing pressure and increase the length of the rotation cycle.

Liveweight/ha/day

Control Treatment

Liveweight/ha/day for the different combinations of length of rotation cycle and grazing pressure on the control treatment, ranged from 1.437 to 9.084 metric tons/ha/day (Table 20).

Liveweight/ha/day shows a decrease ($P<0.01$) with decreasing (Table 21) grazing pressure (high RDM). The amount of liveweight/ha/day was not influenced by length of rotation cycle (Table 22).

The fitted equation for liveweight/ha/day on the control treatment shows a highly significant ($P<0.01$) linear and quadratic effect of grazing pressure. The other terms of the equation were not significant (Table 9 and Fig. 11).

The computed stationary point was detected at 31 days for length of rotation cycle and 3.3 metric tons/ha of residual dry matter (Table 10), with a response at that point of 2.2 metric tons/ha/day of liveweight. The stationary point for liveweight/ha/day on the control treatment is located within the experimental region and is close to the lower values observed in the experiment (Table 20).

Contours of response of liveweight/ha/day are presented in Fig. 11. The contours show that amount of liveweight/ha/day increases with heavier

Fig. 10. Contours of animals per hectare per day on the sprayed molasses treatment.

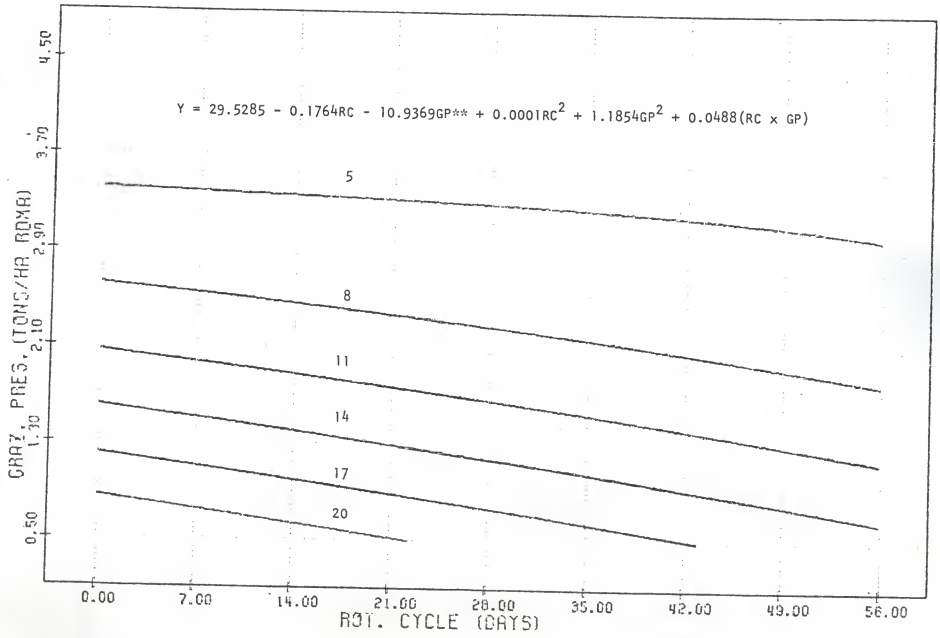

Y = 29.5285 - 0.1764RC - 10.9369GP** + 0.0001RC^2 + 1.1854GP^2 + 0.0488(RC x GP)
5
8
11
14
17
20
GRAZ. PRES. (TONS/HA ROMA)
0.50
1.30
2.10
2.90
3.70
4.50
0.00
7.00
14.00
21.00
28.00
35.00
42.00
49.00
56.00
ROT. CYCLE (DAYS)

Table 20. Observed liveweight per hectare per day for the different combinations of rotation cycle and grazing pressure on the control treatment.

Length of rotation cycle	Grazing pressure RDMA†	Observed liveweight/ha/day
-------days-------	-metric tons/ha	--metric tons---
56	0.771	5.987
56	0.837	6.889
42	2.841	2.512
14	1.339	5.061
28	0.743	8.627
28	0.738	9.084
0	3.579	2.209
0	3.722	2.519
0	2.088	3.196
0	2.449	3.532
14	3.059	3.104
56	3.419	2.361
56	3.665	2.340
42	1.437	5.172
28	3.729	1.437
28	3.795	1.772
28	2.125	2.291
28	2.206	2.506
0	0.789	7.105
0	0.814	6.917
56	2.092	2.890
56	2.073	4.039

† Residual dry matter adjusted.

Table 21. Main effect of grazing pressure on liveweight per hectare per day on the control treatment.

Grazing pressure RDM†	Observed liveweight/ha/day
-metric tons/ha-	---metric tons---
0.5	7.435
1.3	5.116
2.1	3.075
2.9	2.808
3.7	2.106

† Projected residual dry matter.

Table 22. Main effect of rotation cycle on liveweight per hectare per day on the control treatment.

Length of rotation cycle	Observed liveweight/ha/day
-------days-------	---metric tons---
0	4.246
14	4.082
28	4.286
42	3.842
56	4.084

grazing pressures (low RDM). The figure also points out that for a constant grazing pressure the liveweight/ha/day is not influenced by length of rotation cycle.

Molasses Sprayed Treatment

Liveweight/ha/day for the different combinations of length of rotation cycle and grazing pressure on the molasses sprayed treatment is listed in Table 23. The values ranged from 1.305 to 7.988 metric tons/ha.

Tables 24 and 25 present the effects of grazing pressure and length of rotation cycle, respectively, upon liveweight/ha/day. Liveweight/ha/day declined linearly ($P<0.01$) with decreasing grazing pressure. Liveweight/ha/day shows a tendency to decrease with increasing length of rotation cycle (Table 25).

The fitted equation (Table 9 and Fig. 12) for liveweight/ha/day on the molasses sprayed treatment shows a significant ($P<0.01$) linear effect of grazing pressure on liveweight. The interaction between grazing pressure and length of rotation cycle was also significant ($P<0.1$) for liveweight/ha/day.

The stationary point was located at 42 days for length of rotation cycle and 3.7 metric tons/ha of residual dry matter. At that point the liveweight/ha/day was found to be equal to 1.9 metric tons/ha. The stationary point is located inside of the experimental area and is approximately in the middle of the values observed for liveweight/ha/day (Table 23).

The contours obtained for liveweight/ha/day on the sprayed molasses treatment is shown in Fig. 12. They indicate that liveweight/ha/day

Fig. 11. Contours of liveweight per hectare day (metric tons) on the control treatment.

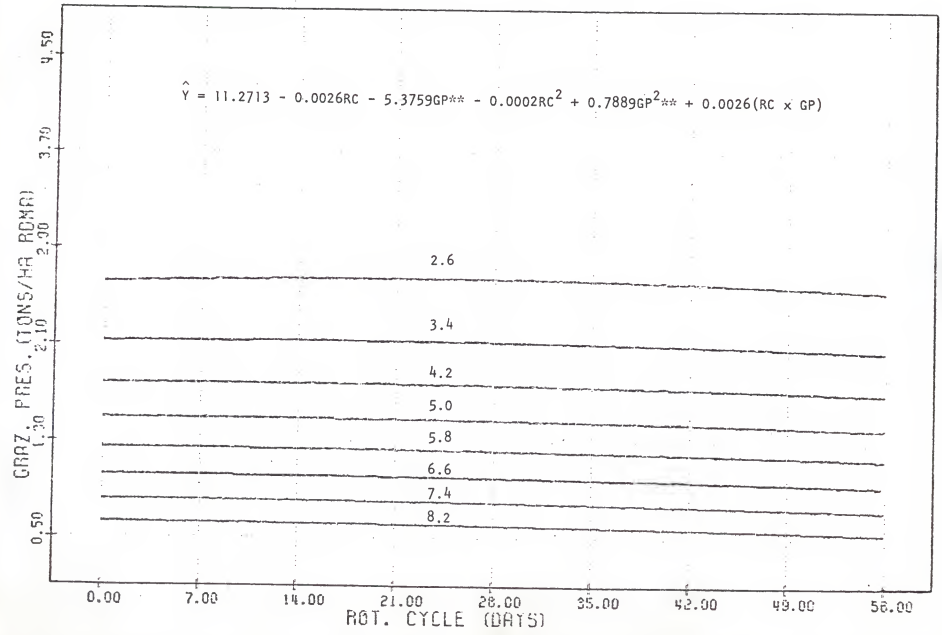

$\hat{Y}$ = 11.2713 - 0.0026RC - 5.3759GP** - 0.0002RC^2 + 0.7889GP^2** + 0.0026(RC x GP)
GRAZ. PRES. (TONS/HA ROMA)
0.50
1.30
2.10
2.90
3.70
4.50
2.6
3.4
4.2
5.0
5.8
6.6
7.4
8.2
0.00
7.00
14.00
21.00
28.00
35.00
42.00
49.00
56.00
ROT. CYCLE (DAYS)

Table 23. Observed liveweight per hectare per day for the different combinations of rotation cycle and grazing pressure on the sprayed molasses treatment.

Length of rotation cycle	Grazing pressure RDMA†	Observed liveweight/ha/day
-------days-------	-metric tons/ha-	--metric tons--
56	0.803	6.102
56	0.814	6.144
42	2.970	2.814
14	1.282	4.938
28	0.712	7.385
28	0.747	7.988
0	3.915	2.044
0	3.819	2.375
0	2.196	2.793
0	2.136	3.478
14	2.988	3.081
56	3.692	1.973
56	3.851	1.932
42	1.233	4.103
28	3.732	1.305
28	3.516	1.844
28	2.194	1.937
28	2.274	2.342
0	0.932	7.414
0	0.804	7.005
56	2.033	3.432
56	1.997	3.496

† Residual dry matter adjusted.

Table 24. Main effect of grazing pressure on liveweight per hectare per day on the sprayed molasses treatment.

Grazing pressure RDM†	Observed liveweight/ha/day
-metric tons/ha-	---metric tons---
0.5	7.006
1.3	4.520
2.1	2.912
2.9	2.916
3.7	1.912

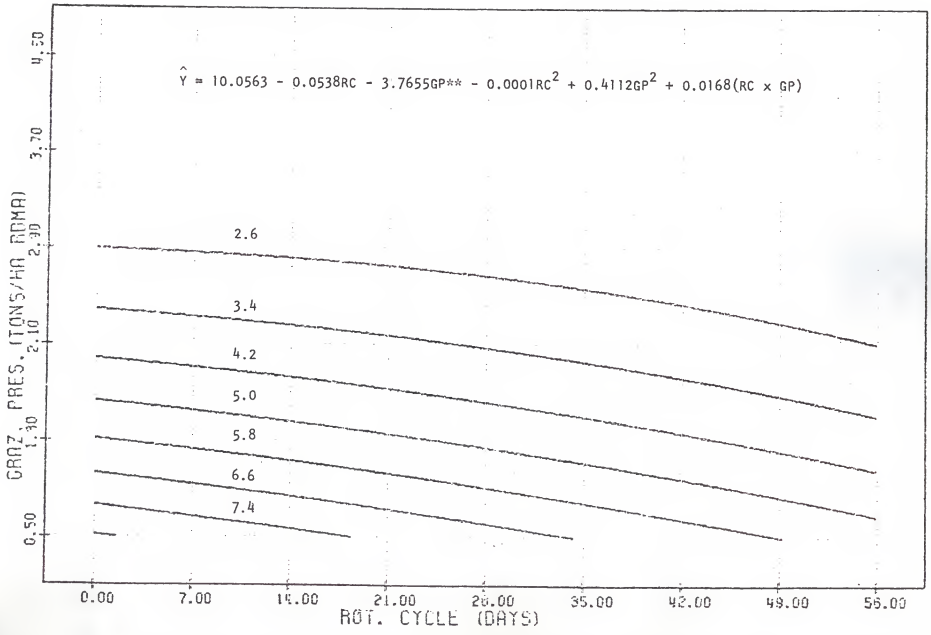
† Projected residual matter.

Table 25. Main effect of rotation cycle on liveweight per hectare per day on the sprayed molasses treatment.

Length of rotation cycle	Observed liveweight/ha/day
-------days-------	---metric tons---
0	4.184
14	4.009
28	3.799
42	3.458
56	3.846

increased with heavier grazing pressures and shorter length of rotation cycle. From Fig. 12 also can be seen that the length of rotation cycle when shorter than 14 days had little influence upon liveweight/ha/day. However, liveweight/ha/day decreased by increasing length of rotation cycle. Liveweight/ha/day is reduced with lighter grazing pressures and longer lengths of rotation cycle.

Fig. 12. Contours of liveweight per hectare per day (metric tons) on the sprayed molasses treatmemt.


$\hat{Y}$ = 10.0563 - 0.0538RC - 3.7655GP** - 0.0001RC^2 + 0.4112GP^2 + 0.0168(RC x GP)
GRAZ. PRES. (TONS/HA ROMA)
0.50
1.30
2.10
2.90
3.70
4.50
2.6
3.4
4.2
5.0
5.8
6.6
7.4
0.00
7.00
14.00
21.00
28.00
35.00
42.00
49.00
56.00
ROT. CYCLE (DAYS)

SUMMARY AND CONCLUSIONS

A grazing experiment was conducted from April to November 1976, at the Beef Research Unit, which is located approximately 21 kilometers northeast of Gainesville, Florida. The experimental pasture was a mixture of bahiagrass (Paspalum notatum Flugge), smutgrass (Sporobolus poiretii [Roem. and Schult.] Hitchc.) and white clover (Trifolium repens L.). The experimental area had an initial smutgrass ground cover between 40 to 50%, which is typical of many pastures in Florida.

The main purpose of the research was to determine the effects of different combinations of lengths of rotation cycle and levels of grazing pressure, and to evaluate the applicability of spraying molasses on the pasture to increase the palatability of smutgrass.

Length of rotation cycle was studied at 5 different levels (0, 14, 28, 42, and 56 days) and grazing pressure at 5 levels of residue left after grazing (0.5, 1.3, 2.1, 2.9, and 3.7 metric tons/ha of dry matter). The combinations of rotation cycle and grazing pressure, each at 5 levels, were arranged in a response surface type of experiment and superimposed upon control and sprayed molasses treatments. The combinations of the 2 factors each at 5 levels made up thirteen different grazing combinations. The thirteen combinations were arranged as 4 factorial, 4 axial, 1 center, and 4 corner points. The axial, center, and corner points were replicated twice, making a total of 22 pastures per treatment. The central treatment was the

combination of a length of rotation cycle of 28 days and a grazing pressure equal to 2.1 metric tons/ha of residual dry matter left after grazing. The 22 pastures were assigned at random within each of the main treatments.

The thirteen combinations of length of rotation cycle and grazing pressure only were superimposed upon the control treatment.

The molasses treatment differed from the control in that molasses was sprayed on the foliage before animals were given access to the pasture at the beginning of each cycle. Molasses was diluted in equal parts of water and sprayed at the rate of 320 liters/ha.

Residual dry matter/ha was estimated after each grazing period by a double-sampling procedure. Twenty random readings (0.186 m^2) were taken in each pasture with a capacitance meter. From these twenty, 4 were randomly selected and harvested. Capacitance meter readings and dry weight of the cut samples were used as independent and dependent variables, respectively, in a regression analysis forced through the origin.

In order to study the effect of the treatments on the change in smutgrass ground cover, 4 non-randomly selected 1 m^2 permanent quadrats were set up in each pasture. A charting method was used to evaluate the change in smutgrass ground cover. Ground cover was estimated in early April before applying the treatments and again late in October. The change in ground cover of smutgrass for each pasture was determined by the difference between the ground cover estimates made in October and April 1976.

The response of the pasture to the main treatments and grazing management was measured in terms of the following response variables: change in smutgrass ground cover, animals/ha/day, and liveweight/ha/day.

Spraying molasses in the pasture resulted in very little increase of palatability of smutgrass when compared to the control treatment. Despite the small effect of molasses, it was observed that the animals showed preference for the sprayed pastures for a few hours after spraying. The lack of a molasses effect may be due to the low rate of molasses used in this experiment.

Smutgrass ground cover on the control treatment decreased primarily with heavier grazing pressure. Little effect of length of rotation cycle was observed.

Smutgrass ground cover on the sprayed molasses treatment decreased with heavier grazing pressure associated with shorter rotation cycle. However, grazing pressure was much more important than length of rotation cycle.

Animals/ha/day on the control treatment increased with increasing grazing pressure. Length of rotation cycle had almost no effect upon animals per hectare per day.

The number of animals/ha/day on the molasses treatment was mainly a function of grazing pressure. However, the number was maximum at heavier grazing pressures associated with shorter rotation cycles.

Liveweight/ha/day on the control treatment increased with heavier grazing pressure. Very little effect of length of rotation cycle was observed.

Liveweight/ha/day on the sprayed molasses treatment was also primarily a function of grazing pressure. Higher liveweights/ha/day were found at heavier grazing pressures in combination with shorter rotation cycles.

The results suggested that grazing management may be a successful way to control smutgrass in pasture. One season of grazing resulted in measurable decreases in smutgrass ground cover due to heavier grazing pressures. Heavier grazing pressure improved vigor and production of desirable species (mainly white clover) by allowing less competition by smutgrass. Under the conditions studied, the animals were stressed and lost weight. The loss of weight observed seems to be related to the very low acceptability of the smutgrass but also in part to the initial large ground cover percentage, and the high quantity of accumulated mature smutgrass at the beginning of the experiment. This suggests that other control methods should be applied in combination with grazing management in order to eliminate the old material before using grazing animals.

Further studies are suggested: 1) increasing the rate of molasses used; 2) changing the time at which grazing starts, in terms of the growth stage of smutgrass (early in the spring); 3) applying other control methods before superimposing grazing management systems, and 4) studying different grazing management combinations to determine animal response (weight changes) for each system.

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He worked as technical assistant in pastures of the Divisão de Pesquisa Zootecnica of the Departamento Nacional de Pesquisa Agropecuaria from 1970 to 1974.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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